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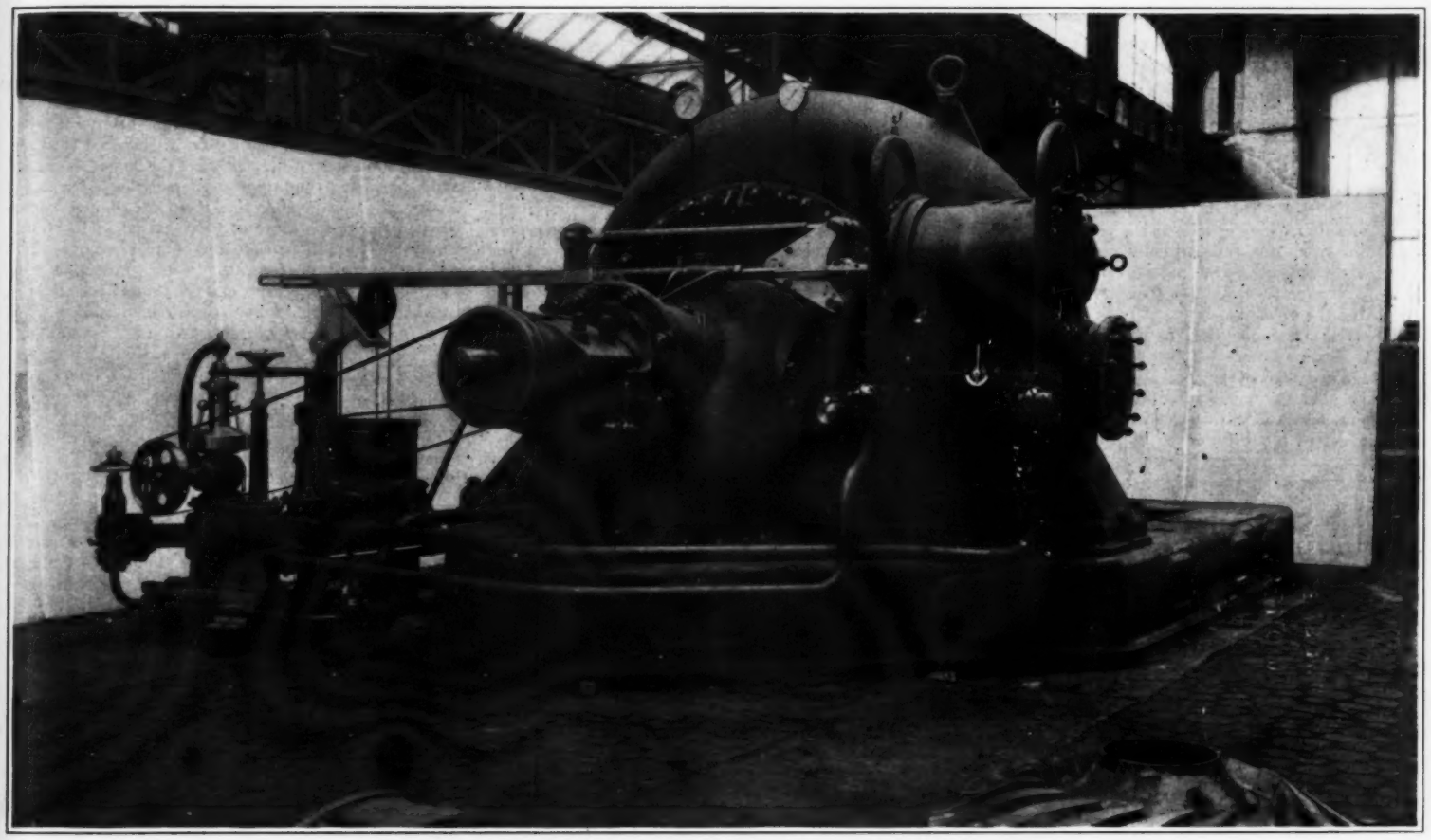

Thirty-two-hundred Horse-power Hydraulic Turbine Working at 205 Feet Head

Three Turbines of 320 Horse-power each; Water-head 99 feet.

MODERN HYDRAULIC TURBINE PRACTICE.—[See page 328.]

The Causes of Boiler Explosions*

The Majority of Accidents are Traceable to Poor Design and Careless Operation

By S. F. Jeter

BROADLY speaking, there is one explanation for all boiler explosions; namely, the boiler or some part of it is too weak to withstand the stress brought upon it. There are many causes contributing to such weakness, and a definite cause can usually be given for most explosions.

Public opinion is being aroused to the fact that many boiler explosions are preventable, as evidenced by the present agitation for laws governing the construction and operation of boilers. The lead of the city of Philadelphia has been followed and improved upon by the State of Massachusetts; also Ohio and several municipal governments now have boiler laws patterned after those of Massachusetts, and similar action is being considered seriously by a number of other States and cities.

FAULTY DESIGN.

One cause of boiler explosions is faulty design, as they are frequently constructed too weak for the pressure to be carried. This does not mean that the boiler will necessarily explode as soon as the pressure is raised. Explosions from this cause usually occur after years of use, the overload on the parts having had time to gradually weaken them until they are no longer capable of resisting the excessive strain.

Of course, a manufacturer has practically no control over the steam pressure to be used on a boiler, after it has been delivered to the purchaser. But if the manufacturer should stamp his name and the safe working pressure for which it was designed on each boiler built, it would act as a protection to his reputation in the event of excessive pressure being used. Proper inspection and fixing of pressures by experts is the logical remedy for explosions due to this cause.

A fault of design which often leads to an explosion is the adoption of a shape which tends to deform under pressure. In such cases, if the movement produced occurs within narrow limits along fixed lines, grooving or cracking is almost certain to occur, finally resulting in an explosion, unless the defect is discovered before the structure has been weakened to the breaking point. The obvious remedy is to use shapes which the internal pressure does not tend to change, and if this is impractical, to use such forms that the movement produced will occur over considerable areas and not be confined to narrow limits.

Improper reinforcement of openings has occasionally been the cause of boiler explosions. If the openings in boiler work were not generally of such moderate dimensions, this might be a more frequent cause of disaster. No definite information is available regarding the distribution of stresses around an opening in a cylinder when subjected to internal pressure; consequently, the design for the reinforcement of such openings is by rule-of-thumb.

Another fact responsible for many explosions is an arrangement not permitting of accessibility for the inspection of all parts. This is especially so when the inaccessible parts are located where rapid deterioration is likely to occur. No portion of the boiler proper should rest directly on a foundation or have any of its parts buried in earth or ashes. Furthermore, a design which does not permit free circulation of water in all of its parts is liable to produce rapid internal corrosion, for unless a current is produced by the circulation sufficiently strong to remove all bubbles of air that may attach themselves to the surfaces, rapid corrosion is almost certain to ensue. This, if neglected, may result in an explosion.

Air, which is a mixture of about four parts of nitrogen to one of oxygen, together with very small quantities of other gases, dissolves to a certain extent in water. However, the oxygen, being more soluble than the nitrogen, dissolves more readily and the proportion of the gases found dissolved in the water is roughly one of oxygen to two of nitrogen, instead of in the proportions found in the air. When the dissolved air is liberated by the heat, the high percentage of oxygen causes the surfaces on which the bubbles may collect, to be rapidly corroded. This accounts for the severe corrosion of vessels containing water which is merely heated without a strong circulation being produced.

A correct boiler design will provide uniform flexibility throughout. A stiff, rigid part next to one which is flexible is a menace to safety if there is any tendency toward movement between the parts, either due to temperature changes or pressure.

POOR WORKMANSHIP.

Defective workmanship is responsible for some explosions, the barbarous practice of drifting rivet holes having doubtless contributed largely in the past to such accidents. The reputable manufacturer of to-day, however, will not knowingly permit such work.

Failure to properly flare the tubes and nipples in water-tube boilers has frequently resulted in explosions. The safety of the joint between a tube and a plate when expanded and flared or merely expanded, is not a question of the relative strength of such connections newly made. When for some reason connected with the operation of a boiler, a connection of this kind becomes loose, owing to a movement of the parts from expansion or vibration, together with the excessive weight sometimes sustained, the tube or nipple with a flared end is decidedly more safe than one which is merely expanded. The flared nipple usually gives warning of its looseness by leakage before it pulls out.

DEFECTIVE MATERIAL.

Defective material is sometimes the cause of boiler explosions, and the boiler manufacturer is largely dependent upon the producer of the material for protection in this respect. Nothing but material of the best quality should be specified for all parts of a boiler which are called upon to resist the stresses produced by the pressure of steam, and every precaution should be exercised to see that such material is obtained. Cast iron should never be used in any part of a boiler called upon to resist tensile stress.

WILLFUL NEGLECT.

A cause of explosion which is particularly reprehensible, because of its being preventable, is due to an owner's willingness to pit his judgment against more competent or conservative advice. Often boilers are known to be in need of repairs, but the work is put off to a more convenient season. A feed pump refuses to start, and instead of fires being drawn as soon as the water reaches the lowest safe level, a chance is taken that it can be run a little longer. Pressures are sometimes carried higher than reasonable safety would permit, to avoid the expense of larger engines, or better boilers. Boilers are forced beyond a reasonable duty for the heating surface they contain. This is a feature that must be reckoned with more in the future than it has been in the past.

NEGLECT OR CARELESS OPERATION.

Boiler explosions are also the result of neglect or carelessness in operation. Scale and deposit are often allowed to collect in quantities that are dangerous; connections to water columns are allowed to become stopped; oil is permitted to enter the boiler with the feed water; repairs to settings which may affect the safety of the boiler are neglected; safety valves are not regularly tested to ascertain if they are in operating condition; or occasionally an owner who discovers the safety valve leaking, with an eye blind to every consideration except the prevention of loss of steam, places a stop valve on the connection to the safety valve or plugs the outlet. A steam gage may register incorrectly and the engineer screws down on the safety valve in an endeavor to make the gage show the correct pressure.

Again, the steam pressure may not be sufficient to produce the results desired and the safety valve is deliberately made inoperative to overcome the difficulty. All of these conditions have been the cause of boiler explosions in the past and they probably will continue to contribute their share in the future until the steam user is more thoroughly educated in the matter of the risk he runs by such carelessness.

TUBE FAILURES.

Tube failures, which are chiefly confined to the water-tube type of boiler, are a source of grave concern to the boiler-insurance interest because it is difficult to guard against the usual failure of this kind by inspection. A defective weld usually does not show on the surface of the tube, and even where the surface indications would lead to suspicion, a large percentage of the tubes in water-tube boilers are beyond the reach or vision of the inspector. The thorough inspection of tubes before they are placed in the boiler, while very unsatisfactory, even taken in connection with the mill test, is about the only protection possible against accidents due to this cause.

The seamless tube will prevent accidents due to defective welding, but tubes made by this process are not always of uniform thickness, and with the cold-drawn product there are apparently internal strains produced by the process of manufacture which sometimes cause the tubes to break when merely heated. If cold-drawn tubes are used for boiler purposes, the annealed stock should be obtained. Hot-drawn seamless tubes are now meeting with considerable favor among engineers for boiler purposes.

A considerable percentage of tube failures occur without the slightest evidence as to their cause. A welded tube frequently breaks through the solid metal away from the weld, without being corroded or weakened in any way that may be detected by the eye, and without evidences of overheating. There must be some reason for such failures.

It is a fact that while pressures and rates of driving have been remarkably increased during the past 15 or 20 years, no increase in the thickness or strength of tubes has occurred. That the thicker tube is safer seems to have been demonstrated by a number of cases where heavy tubes have been used in place of those of standard gage, and tube troubles have ceased. Of course, it can be contended that the theoretical factor of safety is higher on tubes even of standard thickness than on almost any other portion of the boiler. However, under operating conditions accompanying high rates of driving, is it not possible that there are decided fluctuations in the temperature of the material in the tubes? The rapid formation of steam bubbles removes for a certain interval of time the water protection from the inner surface of a tube, and the thinner the material, the higher will its temperature rise during a given time in which it is not protected. It is conceivable that the structure of the metal in a thin tube may be affected in time by this constant change in temperature until it gives out, while the thicker tube might not be affected to the same extent by this means. This idea is only advanced as a possible explanation for some of the tube accidents which seem to defy definite causes being assigned for them.

The thicker material in the case of welded tubes will make it more certain that the required strength is obtained in the weld; also, surface imperfections in the material would not affect the strength to the same degree in the thick tube as it would in the lighter one.

The importance of the question of tube failures to the operator of boilers as well as to the insurance interest can be appreciated when it is realized that the toll of loss of life and limb exacted by such failures probably exceeds other classes of boiler accidents when the relative number of fire-tube and water-tube boilers in use is considered.

OTHER CAUSES.

Corrosion has been the cause of many serious explosions, but with boilers built accessible for inspection, explosions from this cause may be reduced to a minimum where the boilers are under the care of a competent inspection service.

A source of explosions, external to the boiler itself, but which has produced very serious disasters, is the improper arrangement of steam piping. It is very dangerous indeed to attempt to connect a boiler to a steam line where the piping is arranged so that water pockets may be formed. A water-hammer is likely to result in such cases which may break the pipe connections, and this in turn may produce an explosion of the boiler itself.

Very disastrous explosions have been due to hidden cracks or so-called lap-seam cracks. The cause of these defects is either the form of seam, poor material, improper shape of the joined ends of the sheet, or the abuse of the material in the process of manufacture; possibly it may be a combination of some of these causes. That the form of seam alone is not the only factor is well demonstrated by the fact that all lap seams do not fail in this manner and also that some seams of the butt-joint type have thus failed.

It is readily recognized that with every possible precaution, boiler explosions cannot be entirely eliminated, but their number may be lessened materially. A proper inquiry into all accidents of this kind by government officials qualified and clothed with ample authority would tend to reduce the number of explosions.

Colored Coatings for Metal (Metallochromy.—Immerse the platina pole of an electric battery of four to six cells in a solution of sugar of lead or of a manganese salt (1 part of potassio-manganous sulphate, 12 parts of water, or 1 part of chloride of manganese in 8 parts of water, or 1 part acetate of manganese in 15 parts of water) and we shall obtain, on the positive pole, colored rings. The same effect is produced if we connect the positive pole with a platinized metal article. On brass we obtain the colored coatings by boiling litharge in a potash solution of 18 to 22 deg. Bé. and connecting the brass object with the positive pole, the negative pole terminating in a platinum plate immersed in the fluid. From time to time, litharge is added to the fluid. If the current is too strong the coloration obtained is imperfect.

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* A paper delivered before the American Boiler Manufacturers' Association at New Orleans, March 12th to 15th, and reproduced from *Power*.

Steel and Its Heat Treatment*

Changes in Physical Properties Due to Variations in Alloys

By Robert R. Abbott

STEEL is an alloy. In its most simple form it is composed of iron and carbide of iron. Heat treatment, defined according to modern practice, consists of alternate processes of heating and cooling conducted in such a way that the useful properties of the steel are increased in value. This treatment may increase all or part of the properties independently of each other, or it may increase some of the properties at the expense of others.

If a piece of platinum is placed in a furnace which is at a temperature of, say, 2,000 deg. Fahr. it will heat at a uniform rate until it attains the temperature of the furnace; that is to say, if a heating curve be plotted with time as the abscissa and temperature as the ordinate it will consist of a smooth curve. With a piece of steel instead of platinum this will not be so. The curve will contain one or more jogs, depending upon the relative amounts of iron and carbide of iron and to a less extent upon the presence of other elements. The above will be true upon cooling as well as upon heating. The temperatures at which these jogs occur are known as critical temperatures or critical points. A little consideration will show that the jogs are caused by some internal change taking place in the steel, either requiring or giving up energy.

CRITICAL POINTS IN OTHER MATERIALS.

Some analogous cases in other alloys or solutions will probably make this more clear. The change between water and ice occurs at 32 deg. Fahr. This point might be considered a critical point for water. At this temperature the heating and cooling curves show a jog. Liquid copper changes to solid copper at a temperature of 1,983 deg. Fahr. In both of these cases the physical properties of the substance above the change point and below it are entirely different; the specific heat, specific gravity, hardness, color, and state of matter (liquid and solid) are different. Now it might easily be conceived that a critical change could take place, accompanied by all the above changes, without the change in state of matter. Yellow phosphorus, which is inflammable and poisonous, can be changed into a red form by heating it to 432 degrees. This red form is neither inflammable nor poisonous. Upon heating yellow sulphur to boiling and pouring it in water, it becomes a red, soft, gummy substance not unsimilar to rubber. Upon exposure to the air it gradually goes back to the yellow variety. This property of retaining an abnormal state by sudden cooling has an analogous example in steel. If metallic tin is held at a temperature considerably below freezing for a long time it changes to a gray powder. When ordinary iron is heated to 1,420 degrees it changes into a non-magnetic variety, and at 1,650 degrees another change takes place. These three different varieties of iron are known as alpha, beta and gamma, and sufficiently rapid quenching from the right temperature is capable of retaining the beta and gamma form more or less perfectly at the ordinary temperatures. It is thus very apparent that while steel is an alloy composed of two constituents it can really be considered as being capable of forming three distinct series of alloys: namely, carbide of iron with alpha, beta and gamma iron.

ALLOYS AND CRITICAL TEMPERATURES.

The critical temperatures of a substance are usually changed by the addition of another substance. Molten copper begins solidifying at a temperature of 1,983 degrees. This temperature is lowered to 1,920 degrees by the addition of 5 per cent of zinc and to 1,650 degrees by the addition of 30 per cent of zinc, which gives common brass. Consider an alloy of two components, A and B. If the addition of B to A causes a lowering of the critical temperature to A, it is reasonable to suppose that the addition of A to B will cause a lowering of its critical temperature (there are some classes of alloys in which this is not so). Under these conditions it is apparent that there must be some alloy of the series which would have a lower critical temperature than any other. In alloys in which this critical point represents a change in state this one of the series is known as the eutectic. In steel which exhibits a similar phenomenon not accompanied by a change in state it is known as the eutectoid. In our example we will consider that the eutectic ratio is 40 of A to 60 of B. Suppose we have 20 of A and 80 of B, we might consider this 20 of A to be combined with 30 of B to form an eutectic, leaving 50 of B not so associated. This is exactly what does occur and we might consider such an alloy to be composed of an eutectic and either A or B.

The eutectic ratio for steel corresponds to a carbon content of approximately 0.90 per cent. This explains the reason for the importance of slight changes in the carbon contents for a 1 per cent carbon steel instead of consisting of 1 per cent carbon and 99 per cent iron really consists of 15 per cent carbide of iron and 85 per cent iron. When the temperature of a piece of steel is raised above the critical temperature at which gamma iron is formed, we have an alloy formed of gamma iron and carbide of iron. The eutectoid no longer exists but in its place is a homogeneous solution which goes by the name of martensite. This can be retained to a greater or less extent by sudden cooling or quenching and is an important constituent of all heat treated steels at some point in the process of their treatment.

WHAT HEAT TREATMENT INVOLVES.

Broadly speaking, heat treatment consists of obtaining different physical properties in the same steel by varying the relative amounts of the different series of alloys present. This may be done in several ways. Usually the steel belongs originally to the series containing the alpha iron. A definite amount of this can be changed to the gamma or martensite series or all may be changed to this series and then part brought back. Combinations of these two methods are also used.

TEMPERATURE MEASUREMENT.

Since the temperatures of the critical points is of extreme importance in heat treating, it is evident that we must be able to measure high temperatures with a considerable degree of accuracy. For this purpose pyrometers are employed. There are four general types of these: Thermocouple, resistance, radiation and optical. The most widely used of these is the thermocouple type.

Thermocouple: In general if two dissimilar metals are placed in contact there is created a difference in electrical potential at the other ends. This difference is a function of the temperature of the ends in contact, so that if the milli-voltmeter be standardized to read in temperature degrees instead of milli-volts it can be used for temperature measurements.

The critical points are obtained in various ways. The most common and least valuable method as far as heat treating is concerned consists in finding the jog in the heating or cooling curve by means of an ordinary thermocouple and plotting the temperature against the time.

This method usually fails entirely in getting the critical point in low carbon steels which are the most important from a heat treating standpoint. The magnetic critical point can be obtained by means of a common magnet and a pyrometer more or less roughly. It is of very little value for the low carbon steels, as this critical point is not the one used for general heat treating. An extremely accurate method of detecting critical points in low carbon steels is as follows: A neutral body having no critical points, such as nickel, is placed in the furnace side by side with the steel. Three thermocouples are connected in series and with two other couples is placed a very sensitive galvanometer having a full scale deflection equal to about 5 degrees, while the third couple is connected to a regular pyrometer galvanometer or milli-voltmeter with a deflection equal to about 2,000 degrees. This is to determine the temperature at which the critical point occurs. As the temperature of the steel rises, the temperature of the nickel rises with it, and consequently if not heated too fast they will both be at the same temperature at any given time and the voltage generated by the couple in the nickel will neutralize that generated by the couple in the steel and as a result no current will flow. However, when a critical point in the steel is reached, its temperature will momentarily lag behind that of the nickel, with a resultant flow of current through the sensitive galvanometer. The temperature at which this occurs is then read off on the other instrument. Means are usually provided for making a photographic record of the position of the critical points. This is known as the differential pyrometer method. The most accurate method of obtaining critical points is by means of the microscope. This requires an extremely accurate pyrometer and a thorough knowledge of the theoretical constitution of steel.

RESULTS OF HEAT TREATMENT.

We will now consider some of the effects of heat treatment. The elastic limit of a piece of steel is a measure of its value in sustaining a dead load constantly. The maximum strength is a measure of its ability to withstand a load in excess of its elastic limit. The reduction in area is a measure of its ability to withstand shocks (other things being equal) and also of its ability to bend without fracturing. In common language it is considered as a measure of the "toughness" of the steel. The elongation is quite frequently used as a measure of properties similar to that given for elastic limit. This is not as accurate as the reduction in area. A measure of the steel's ability to withstand recurring shocks and strains is best obtained for practical purposes by a combination of the above physical properties considered together with the chemical composition and then by the physical condition of the steel as shown under the microscope.

The specific gravity of a piece of heat treated steel is lower than before treatment. This is equivalent to saying that heat treatment causes an expansion in the steel. According to the shape of the piece, this expansion may take place entirely in one direction and cause an apparent contraction in the other. The amount of this expansion is dependent to a great extent upon the chemical composition. By repeated heat treatment of a certain kind, steel can be caused to shrink.

The stiffness of a piece of steel cannot be increased by alloying nor by heat treatment. By this I mean that, provided the elastic limit is not exceeded, the amount of deflection for a given load cannot be decreased. However, heat treatment will raise the elastic limit so that a much greater load can be carried without causing a permanent set. Until the elastic limit is reached all steels, no matter how treated or of what nature, will deflect the same amount under the same load. However, the poorer grade steel or the un-heat-treated one will reach its elastic limit first and will then deflect much more and retain a permanent set.

When certain alloying elements are added to steel remarkable results are produced. With the same degree of toughness, the strength can be enormously increased and with the same degree of strength the toughness can be likewise increased. These alloy steels show up their remarkable properties to a greater extent when they are heat treated. Immense quantities of alloy steels are used in an un-heat-treated condition. This alloy steel is several times as expensive as the plain steel and yet we could get the same properties from the plain steel by the proper treatment.

If we endeavor to increase the physical properties by means of increasing the carbon contents, we find that it can be done only imperfectly and at a large decrease in the reduction in area or toughness.

The tremendous importance of heat treating all kinds of steels is recognized on all sides. It not only means a saving in money but a saving in weight, as well as a steel which will be far superior in resistance to fatigue. Steel rails are now being heat treated as well as splice bars for joining rails. No one can doubt that the future will be an age of heat treated steels both in the plain and alloyed forms.

*Extracts from a paper read before the Cleveland Engineering Society, Cleveland, Ohio, April 23rd, 1912, and published in *The Iron Age*.

Public Health a Purchasable Commodity

THE amount spent by a municipality in maintaining its public health work has a very direct result upon the degree of efficiency of the work. Whatever may be said about misappropriation or misuse of public funds, very little scandal is found in the newspapers with regard to the money matters of a board or department of health. Possibly, this is due to the fact that the total sum available is liable to be so small as not to excite the cupidity of anyone.

The following table, taken from the monthly *Bulletin of the New York State Department of Public Health*, shows the per capita expenditure for public health work in nine of the cities of this State. It will be seen that the figures range from 56 cents a head down to 11 cents. Ex-Commissioner Dixon, of Chicago, has stated that adequate work could not be done for less than 25 cents a head; a paper presented at the last annual meeting of the American Public Health Association suggested as the result of a careful analysis, 45 cents a head was as little as could be spent to maintain an efficient health department engaging in the many and varied activities that now fall to the lot of such:

Name of City.	Population.	Per Capita Expenditure Health Work Per Annum.
New York City	4,956,865	$0.56
Buffalo	435,315	.37
Rochester	227,103	.33
Syracuse	142,110	.55
Albany	100,859	.11
Yonkers	84,361	.51
Utica	77,088	.19
Troy	76,947	.19
Schenectady	76,447	.29

A Dressing for Razor Strops is made by melting together 1 part of yellow wax, ½ part of resin, ½ part of thick turpentine, 2 parts white soap, 2 parts olive oil. To this add 1 part English red, 5 parts emery, 1½ parts pumice stone, 2 parts blood stone, 4½ parts graphite, and stir all together.

Perfume from Flowers

How the Amateur May Prepare His Own Extracts

By S. Leonard Bastin

HEARING from grown up folks that perfume was obtained from flowers, most of us as children must have tried our hands at scent making. Collecting a handful of petals from the borders we have put these with some water in a bottle, shaken all up together and hoped for great things. Alas how keen has been our disappointment when we have found that nothing results but a most evil smelling liquid not in the least like the fragrant perfume which can be bought at the stores. After all, however, most things are simple enough if one only knows how to set about them, and to the ordinary person perfume extraction should not present many difficulties. Of course it should be understood at the outset that very few scents sold in the stores are simple essences; nearly all these are the result of skilful blending, an art which requires a good deal of ingenuity. Still by following the line indicated in the present article it will be found quite easy to extract the sweet scents of our common garden blossoms, and to preserve these delicate odors in a permanent form.

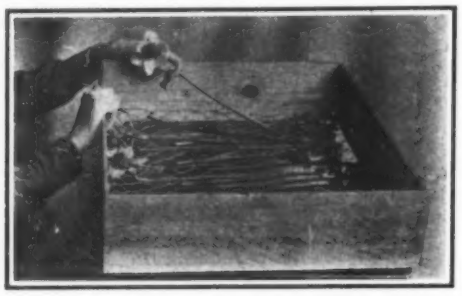


Fig. 1.—Spread the Flowers Out on Wire Netting and Dry by Swinging To and Fro in the Air.

Generally speaking it will be possible to gather scent from any blossoms which are fairly strongly scented. Better results seem to be obtained in some cases than in others, it being a fact that in certain blossoms the perfume is of a curiously elusive nature. Roses, violets, lilies, tuberose and lavender may be mentioned as good examples to try in the first instance. It is important to cull the blooms at the right time as much depends upon this. In nearly all cases there is a short period when the fragrance is in a more intense form than at any other time and it is then that the gathering of the flowers must take place. It is generally thought that the blooms will smell most strongly immediately after they have opened but this is not the case. It is far better to wait until the organs of the flowers have become fully matured, and it is then that the scent will be at its best. Certainly a point should be made of securing the petals in the forenoon before the heat of the day has in any way faded them. It is very necessary that the flowers should be quite freed from any traces of rain or dew. It is a rather delicate matter drying the flowers as unless the process is done quickly the petals will wither and the natural fragrance depart. For the purpose of drying it is a good plan to prepare a framework with wire netting stretched across on the lines of the accompanying illustration, Fig. 1. Into this the blossoms may be placed in a single layer and the whole thing moved up and down with a swinging motion so that the air rushes freely around the blooms. In a short while it will be found that all traces of moisture, which is almost certain to have been present if the flowers have been gathered early in the morning, will have gone.

It will now be necessary to obtain some very pure Lucca oil. A great deal depends upon making quite sure that the material is genuine olive oil; much of the cheaper stuff on the market to-day is refined animal oil and not at all suitable for our purpose. The highest grade vegetable oil is in itself practically scentless and will moreover be found to take up the delicate essences of the flowers quite readily. The next step is to secure some pieces of wadding such as may be purchased at any draper's stores in lengths. Last of all we shall need some wide necked jars; those made of glass are the best although this is not an essential point. Now with a sharp pair of scissors cut the wadding into circular portions such as will easily fit into the jar. A good number of these should be prepared beforehand. Next pour a quantity of oil into a dish and in this immerse the pieces of wadding. (Fig. 2). As it is desirable that the wadding should be well soaked it is a good plan to leave them for a while. Meantime we may come back to our flowers. Taking care to injure the petals as little as possible, pick each blossom to pieces. Be very certain to use only the parts of flowers, and in order to make sure that no bits of stalk or leaves are included it is wise to sort out the petals on a tray before making any further advance.

Everything is now ready, save that a small quantity of table salt finely powdered should be at hand. Be quite sure that the jars are quite clean, and then sprinkle a thin layer of the salt on the bottom of the first jar to be filled. Now cover the salt with a layer of petals, and over this place a section of the oil soaked cotton wool, then sprinkle a little more salt, next arrange another layer of petals to be followed by more wadding. (Fig. 3).

Fig. 3.—Place the Petals and Layers of Wadding Alternately in a Jar.

This routine is to be repeated until the jar is full and in order to get a number of sections of wadding into place it will be necessary slightly to press the contents of the jar. We must now make quite sure that the contents of the jar are protected from the action of the air. A large cork answers the purpose well but in any case parchment or grease proof paper fixed over the opening is quite sufficient. When all the jars which it is intended to fill have been prepared they should without any delay be sealed down as it is unwise to leave them open even for a few hours. Now find a shelf on which the receptacles may stand, this should be in a warm place, and if it is possible to get a sunny position so much the better. As a rule it will be found that the more sunshine the petals are subjected to, the better. An upper shelf in a greenhouse will be found to be admirably adapted for this sunning process.

The jars of petals must now be left at least ten days or a fortnight. At the end of this time the vessels may be unsealed and the oil drained away from the saturated wadding. It is a good plan to tie a piece of fine muslin across the mouth of the jar (Fig. 4), but before doing so it is well to press the wadding with a spoon or some instrument so as to drive the oil from the material into the body of the jar. It will be found that the expressed oil is very highly perfumed, according to the kind of flower which has been used; indeed the quality of the scent made on these lines is much more lasting than that which is usually purchased. As soon as possible the essence should be stored away in tightly stoppered bottles. If desired the perfume may be made more convenient for certain purposes by dilution. To bring this about add a quantity of pure spirits of wine to the oil. About one part of the fragrant oil should be added to three or four parts of the spirit, and the whole thoroughly shaken up in a large bottle to insure mixing. After a while it will be noticed that the oil becomes broken up into very small particles and is finally distributed. The mixture should of course be placed in absolutely air-tight bottles.

Fig. 4.—Drain the Oil Slowly Through Muslin After It has Stood for Several Weeks.

Fig. 2.—Soak Pieces of Cotton Wool in Pure Olive Oil in a Dish.

As has been indicated a large part of the art of scent making consists in judicious blending. Certain of the strongly aromatic herbs will, if properly used, add much to the value of some scents. The most difficult point is to keep the various values in the right proportion so as to avoid an undue predominance of any one. A very pleasing fragrance may be made by combining rose leaves and lavender together, only of course to secure the proper results we must employ less of the aromatic herb than of the delicate rose petals. A few pinches of the lavender scattered over every layer of rose petals will be quite sufficient to give the desired zest to the perfume. In the same way a small quantity of rosemary or bay leaves improves the fragrance of violet perfume, although the result is liked by some people more than by others. It is very necessary in adding the leaves of any plant to see that they are perfectly macerated. Each leaf should be cut off separately, and allowed to fall into a basin, care being observed to take only those leaves which are fully matured. It is not a bad method to cut the leaves up into small pieces and in this way help to set free the fragrant oil. As a final measure there is nothing so good as a thorough beating of the foliage with a pestle. (Fig. 5). This bruising with the pestle and mortar should be continued for some time until the scent from the leaves is of considerable strength.

Certain substances to be obtained at the chemist's store will also help us to improve the perfume of natural essences which may not be very powerful for some reason or another. Cloves added to the jar of petals will assist in giving a remarkable piquancy to the resulting scent obtained by some of the methods indicated above. It goes without saying that some chips of the substance usually known as "orris root" will give an enhanced value to violet perfume without in any way indicating that the scent is other than perfectly natural. It will be found that all perfumes improve by storing and many rather feeble scents become strangely intensified after keeping for a week or so. All scent makers are at times mystified by the fact that certain perfumes will lose all their fragrance for a short while. It is quite likely that some of the homemade scent may after an interval part with the best of its fragrance; fortunately, however, this is only a temporary matter and quite often the odor comes back in an intensified form. At present it is quite impossible to explain this phenomenon which to say the least of it is distinctly a curious one especially to the amateur dealing in perfumes.

Fig. 5.—Aromatic Leaves Should be Well Bruised with a Pestle.

The Reality of Molecules

How an Abstract Conception of the Ancients Has Become a Concrete Fact

By Dr. Alfred Gradenwitz

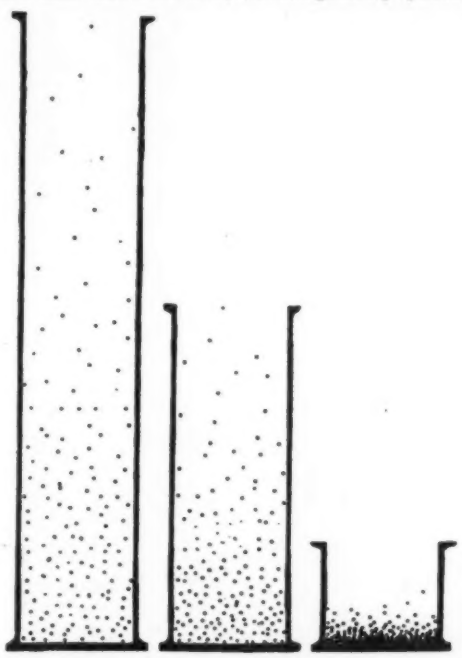
THE increasing magnifying power of microscopes has enabled the innermost structure of objects to be investigated in its minutest details, revealing to the marveling eye of man a new world of the infinitely small. In spite, however, of unceasing progress in every field of microscopic research, there are unsurmountable limits to the possibilities of that wonderful instrument. In fact, calculation shows the absolute impossibility of constructing an optical apparatus which would allow the ultimate particles of matter to be discerned, and it thus seems at first sight as if a proof positive of the existence of molecules and atoms could never by any manner of means be furnished. What however is beyond the reach of microscopes has been recently achieved by a French scientist, Prof. J. Perrin, of Paris University, with the aid of an ingenious indirect method, the description of which reads like a fairy-tale.

About twenty-five centuries ago, at the very beginning of Greek civilization, there lived on the coast of the Ægean Sea, some dreamers who without any experimental knowledge or apparatus, merely guided by intuition, realized that matter, in its changing forms, is made up of indestructible particles, in a state of unceasing motion, of *atoms* so associated with one another as to form the manifold objects of Nature. This theory, after having lapsed into oblivion for about two thousand years, has been revived by modern science, and the hypothesis that matter consists of indivisible particles, atoms and molecules, has become the backbone of all scientific investigation. Yet, no actual evidence had, until recently, been obtained for the existence of these infinitely small particles and the supposed motions of molecules so far escaped the searching eye of experimenters, much as the wave motion of the sea cannot be noticed by too remote an observer. Still, if some ship happens to be in sight, the same observer may be able to perceive a fluctuation, giving evidence of the wave motion invisible to his eyes, and in a similar way, there was some hope of ascertaining molecular motion from the impulses given to somewhat larger, though still microscopical, particles. This, as shown by Prof. Perrin, is the case of Brownian motion, a phenomenon whose intimate nature had so far been misunderstood.

If some heavy object, of spherical shape, say, be dropped in a liquid, it will fall down to the bottom with a velocity which will be the smaller, the less the diameter of the sphere. If, however, a liquid with minute particles floating therein be examined under the microscope, these particles will be found not to fall or rise, but to perform an unceasing motion of seemingly irregular character. If the particle be numerous, they look like swarms of animated points, flitting about and dancing to and fro in ceaseless motion. This is what is called Brownian motion and on this phenomenon Prof. Perrin's work is based.

According to Perrin, each particle behaves like an enormous molecule, so that the system of suspended particles, like a true solution, must obey the laws of gases.

It is a fact of common knowledge that mountain air is rarer than that at sea level, and that generally speaking, a column of air or gas is compressed under its own weight, so that its density gradually becomes less with increasing height. The law which connects the density of a particular portion of gas with its level above some selected zero level may be stated in the following form: "As the distance above the datum level increases in arithmetic progression, the density decreases in geometric progression." Thus in air at ordinary temperature the density is found to decrease by one-half, with any rise of 6 kilometers (3.7 miles). However, the rise producing a given rarefaction varies according to the nature of the gas. In an oxygen atmosphere at 0 deg. Cent., the density thus decreases by half, for each rise of 5 kilometers (3 miles), whereas in an atmosphere of hydrogen, a gas having molecules 16 times lighter, a rise 16 times higher would be required to obtain the same fall in density; in fact, this rise varies inversely as the molecular weight. If then Perrin's hypothesis be true, an emulsion that is a liquid containing minute solid particles will behave like a miniature atmosphere in which the height of the Alps would correspond to a few thousandths of a millimeter. More accurately speaking, it will be an atmosphere with enormous molecules and an enormously rapid falling off in density.



Equal Numbers of Molecules of Hydrogen, Helium and Oxygen Spread Over Columns of Different Height as Indicated in this Diagram.

The truth of this theory has been confirmed by observations on a number of emulsions with one of which the decrease in density by half was found to correspond to a rise of 5 hundredths of a millimeter. Though each of these particles in Brownian movement has a diameter of only a few thousandths of a millimeter, it weighs 100 million times more than a molecule of oxygen, and as this particle, by numbering those contained in a given mass, can be accurately weighed, the weight of the oxygen molecule itself is found with great accuracy.

Each of the emulsions investigated by Perrin gives the same figure and as this practically coincides with that resulting from the kinetic theory of gases, his theory is incidentally confirmed in a most striking manner. The weight of the hydrogen atom (or half the weight of a molecule of hydrogen) would thus be

1.47/1,000,000,000,000,000,000,000,000 gramme.

As other phenomena of the most diverse character, diffusion of dissolved bodies, blue color of the sky, electrification of minute drops, radiation of black bodies and radio-activity, also lead to the same figure, the reality of molecules and atoms can thus be considered as definitely established.

The Hugest Mammoth Ever Exhumed

The Skull Alone Weighs Fifteen Hundred Weight

THE Royal Natural History Museum, of Stuttgart, has recently placed on view in its new annex the largest skeleton of the long extinct mammoth ever discovered.

The director of the museum, Dr. Eberhard Fraas, contributes an article upon the subject to *Die Woche* (Berlin, March 9th). Dr. Fraas is one of the most eminent paleontologists in Europe, and is well known in this country, where he received part of his professional training. In an address made by him recently before a scientific body he referred in terms of the warmest appreciation to the pleasure and profit gained from his sojourn in America, making especial mention of Prof. Henry Fairfield Osborn of the American Museum of Natural History.

The great skeleton just erected under the direction of Dr. Fraas was discovered in the diluvial deposits of sand and gravel at Steinheim on the river Murr, a tributary of the Neckar, a locality long famed for the richness of its fossil remains. The first bones were found in August, 1910, and the excavation of the complete skeleton was carried out with painstaking care. The bones were so friable that it was necessary to reinforce them with plaster of Paris, strengthened by iron rods before attempting removal. The combined mass was then conveyed to Stuttgart with great care. The skull alone, together with its packing, weighed 15 hundred weight.

"By the first of September," writes Dr. Fraas," the whole was removed, and then began months of work to free the bones, to harden them by the use of suitable solutions, and to mend the broken places.

"By the beginning of December, 1911, the erection of the skeleton could be begun. Heavy iron rods were bent at right angles to form a support for the bones; a great scaffold was needed in order to fasten in the right position the heavy skull with its powerful tusks 2½ meters in length (about 7 feet), and it took weeks to get every part of the skeleton in its right place.

"Now the Colossus, the greatest mammoth the world has ever seen, rears itself magnificiently to a height of more than 4 meters (over 13 feet).

"The mammoth, that popular giant of the diluvian animal-world, is known to us better than any of its contemporaries, not only from countless finds of teeth and bones, but also from the drawings of the first artists of the Stone Age, and by carcasses completely preserved, even to the skin and hair, in the Siberian ice. We know with certainty from these discoveries that the mammoth was a long-haired elephant suited to the cold epoch then prevailing on the earth and inhabiting not only the whole of Europe, but northern Asia and America in vast herds. Its most striking feature consisted of the astoundingly long tusks curved in the form of a spiral. These were at times over 4 meters (13 feet) in length, and their great size has led to the erroneous supposition that they belonged to an elephant far surpassing those of to-day, This, however, does not correspond to the facts, for, though there existed among them then as now a number of huge old bulls, on the whole there was little difference between the mammoth and the African elephant of to-day. Of course the herd contained individuals of varying sizes and both male and female. The tusks of the male were distinguished by their greater size and thickness, those of the female being thin and slender and usually much shorter.

"Remains of mammoths are by no means rare, and rich deposits exist in Germany as well as in Siberia, where the tusks form an important article of commerce as fossil ivory. The vicinity of Stuttgart is especially rich and has been noted for such finds for over 200 years. But these have consisted of isolated teeth and bones, mostly in a bad state of preservation, and until lately no complete skeletons were found.

"All the greater is the reason for rejoicing that during the past year three whole skeletons have been mounted in Germany, one at Münster in Westphalia, another at the Museum of Folk Lore in Leipsic, and now this Swabian giant, far surpassing both of these, as well as those in St. Petersburg, Brussels, Budapest and New York.

"This new find is that of a peculiarly long-legged animal, to be regarded as an individual type and a predecessor of the true late diluvian mammoth. Also, it does not exhibit the ugly excessively curved tusks. The tusks show a well-shaped semi-circular curve, with the points bent slightly inward.

"The body is short and compressed, and the remarkably long legs,—the upper fore leg or *humerus* is 1.42 meters (over 4½ feet) long,—indicates a good runner, who could cover with speed the tundras and steppes that marked the Swabian lowlands at that period.

"It is difficult to say positively whether this animal ever came in contact with man, for we have only one find of human relics belonging to that epoch, namely, the lower jaw of the Heidelberg man, *Homo Heidelbergensis*, and we must conclude that at all events human occupation was sparse.

"The period dates back many centuries before the recognized Stone Age, with the races of Neanderthal, Spy and Krapina, and if we place these according to the archæologists from 80,000 to 100,000 years ago then the mammoth from Steinheim has an antiquity of from at least 200,000 to 300,000 years."

Wax Mass for Engraving on Glass.—*a.* Melt 7 parts of Venice turpentine and 15 parts of mastic together in an enamelled vessel, and after they have become fluid, add, constantly stirring, 4 parts oil of spike. *b.* Thirty parts white wax, 15 parts mastic, melted together; also dissolve 7 parts of asphalt in 2 parts of Venice turpentine, and mix the two, stirring constantly.

The Photographic Industry*

Its History and Development

By Dr. C. E. Kenneth Mees

THE position of the photographic industry among the chemical industries is a somewhat peculiar one. While essentially a branch of chemistry, the nature of the product and the methods of production are distinct from those employed in other chemical industries, so that the photographic industry has evolved a complete technique of its own, with its own machines, its own type of factory, and its own methods of testing the products, methods which bear little relation to the usual analytical processes of the chemist. Moreover the photographic industry has from its origin been a secret industry, the working methods of which have never been published, and the technique of which is largely unknown to the majority of scientific men other than those of the industry itself. While, in spite of it, some factories have undoubtedly developed to a very high state of organization, this secrecy must also have reacted upon the industry as a whole, tending to inefficiency and a vast amount of unnecessary waste and difficulty, which the lack of free exchange of knowledge must bring in its train.

The industry at present is developed chiefly in England America, France, and Germany, though there are a number of scattered factories in other parts of the world. Climatic conditions, however, have tended to restrict manufacture to the temperate regions, although at the same time, the fact that photographic products are, on the whole, unstable, causes constant attempts to be made to erect factories wherever a ready market can be found, and the centralization in selected localities, which is so typical of such industries as the steel industry, is less marked in photographic work. On *a priori* grounds it might be expected that the photographic industry would have been developed near districts producing its chief raw materials, glass and paper. But a survey of the position brings out very strongly the fact that the history of the photographic industry is a history which hinges round men, and round very few men. Where the early manufacturers started, there the business has remained, and the new firms which have sprung up have mostly been offshoots from some one or other of the older factories; so that the two main original centers of the industry as a whole, have been London in England, and Rochester in the United States, while in France, Lyons has developed as a great photographic center.

The typical history of the photographic material business has been somewhat as follows. In the first place, we have an amateur, or, more generally, a professional photographer making the materials which he required for his own business. Next, finding that the manufacture of the materials was more congenial or more remunerative than the pursuit of his own avocation, he supplied other photographers of his acquaintance, and then for a number of years may have carried on a small business employing three or four people, generally girls, and either making the emulsions himself, or, what was commoner, getting his wife to make them for him. It is an interesting fact that in most of the original photographic factories, the emulsions were made by the wife or daughter of the owner, generally for the obvious reason that they could better be trusted than any outsider. With the replacement of hand coating by the coating machine, came production on a factory scale. The owner of the business usually weighed out all the chemicals required, keeping the formulæ strictly to himself, and comparatively small factories organized on these lines have for many years been the backbone of the photographic industry, indeed, it is largely to such factories that we owe the high standard of product which has been reached to-day. But, as in all other businesses, the day of the small factory is practically over, and the future of the photographic industry is to the modern factory, employing hundreds of workpeople, manufacturing on a vast scale and at low costs, and using specially designed machinery at every step of the process.

It is difficult for those who regard photography as an occasional hobby to realize to what an extent it has developed as an industry; but even as a chemical industry it is not to be despised, as is evident from the fact that one factory in England alone orders its potassium bromide in thirty-ton lots, and that one company is the largest user of silver except a Government mint; that the production of the biggest English photographic paper factories is counted in miles per day, and of plates in acres. In this, as in all other industries, the question of the available supply of raw material is a serious one. Just as one of the great dye works refused to use toluol as the raw material for a new product because the world's production of toluol was insufficient to supply the market, so one great photographic firm, after many costly experiments, abandoned a new paper, because the whole world's supply of fucose would not have kept them running for three months. And so to-day I may rightly claim that the photographic industry is not only a chemical industry, but is a great chemical industry numbering its workers by the thousand, and its products by the ton.

CHEMICAL NATURE OF THE PROCESSES INVOLVED.

The photographic industry is an industry based on colloidal chemistry, its nearest relatives among the chemical industries being apparently the production of rubber and of high explosives, although when looked at from the standpoint of factory organization, no two industries could be more diverse than the photographic one and the explosives industry, the factory organization of photography being concentrated to a degree, while the dangerous nature of the explosives industry necessitates the segregation of almost every individual worker in a separate building. so that whereas an explosives factory may occupy a square mile or more of land, a photographic plate factory is simply a cubical block of building. The fact that the work is conducted in darkness, renders arrangements for external lighting superfluous, the chief problem in the erection of a photographic factory being the supply of a sufficient quantity of pure, dust-free air to all parts, by means usually of forced draught, with appropriate heating, cooling, and purifying appliances.

As by far the greater portion of the photographic industry deals with the light-sensitive properties of salts of silver, and as I have no practical acquaintance with those sections of the industry which deal with other salts than those of silver, I propose to restrict my remarks to the processes involving the use of silver compounds. Essentially the production of sensitive photographic materials relates to the behavior of silver salts when they are converted from the colloidal condition to the crystalline, the conversion being retarded and regulated by the suspension of the salts in gelatin, and complicated by the changes simultaneously undergone by the gelatin itself. Dealing first with the production of high speed photographic plates—the branch of industry with which I have the most practical acquaintance—the process is briefly as follows. A concentrated solution of potassium bromide, usually dimolecular, is made, and to this is added a small quantity of gelatin, the amount being sufficient to prevent the complete deposition of the silver bromide when a concentrated warm solution of silver nitrate is added. Now, if instead of using dimolecular solutions, much weaker solutions, say, quintmolecular, are used and gelatin is added to the silver solution as well as to the bromide solution, then on mixing the two solutions the resultant mass will be quite transparent, showing only slight opalescence, and in such an emulsion the whole of the silver bromide will be in a state of colloidal suspension. With greater concentration of the solutions the bromide will be precipitated in a state of greater agglomeration, but it may be assumed that even with the concentrated solutions generally used for making emulsions, a certain amount of the silver bromide precipitated is at first in the colloidal condition. Now if the newly mixed emulsion is kept at a moderate temperature for a short time it will, as the emulsion maker says, "go over," this "going over" being manifested by an increase in the optical opacity and a change from a red color to a white when a flame is observed through a thin film of the emulsion on glass. This "going over," which appears to be the fundamental change in a photographic emulsion, would seem to indicate that the silver bromide was no longer in the colloidal state, but had become entirely crystalline, and a further digestion of the emulsion, during which the optical opacity decreases, and the color of the flame tends to become bluer, appears to be associated with an aggregation of the silver bromide into larger crystalline agglomerates, with a progressive elimination of the originally formed small crystals, the change from a physico-chemical point of view being apparently a concentration of energy into large crystals, which, the concentration being an endothermic one, are really in an explosive state, the simplest explanation of the formation of an image by the action of the very small quantity of light energy required to make a fast photographic plate developable, being apparently that this additional energy is sufficient to initiate a decomposition in the silver bromide crystals by a mode analogous to that in which a detonator causes the decomposition of an explosive mass.

It is, consequently, each individual grain which must be regarded as the analogue of an explosive cartridge, and the film may be likened to a sandbank in which many cartridges are imbedded at various depths, each cartridge being isolated from all others, so that its denotation is not communicated. In such a bank the effect of a shock incident from above (represented by the number of cartridges exploded), would be proportional to its intensity, each separate cartridge, however, being completely shattered if the shock is sufficient to explode it at all.

The unit of the image, which I have been referring to as a large crystalline agglomerate, is the silver grain of the photographic plate; when it is referred to as large, it is only so in comparison to the units of colloidal suspension, for instance, because in comparison with visible crystals it is extremely small, the diameter of average grains being of the order of one thousandth of a millimeter, and the grain itself would appear to be a complex structure, consisting of a number of crystals, and quite possibly containing gelatin. It is probable that photographically each grain is a self-contained unit, attackable by the developer only if it has itself been exposed to light, and that the sensitiveness of an emulsion is a statistical average of the sensitiveness of the individual grain of which it is composed.

It is impossible here to enter into a discussion of the theory of the latent image or of development, and I have introduced it at all only because of its bearing on the reactions involved in the making of an emulsion, the fundamental process of the photographic industry.

Photographic papers may be divided into two classes. The older papers, or print-out papers, on which the print is made by exposure to daylight. the color of the deposit being afterward modified, usually by the deposition of gold upon it; and the later class, now rapidly supplanting the former, in which an emulsion, similar to a plate emulsion, is coated upon paper instead of glass, and the image obtained by exposure for a short time to a weak light source is developed. Print-out papers consist of a silver chloride emulsion precipitated in gelatin or collodion, generally in the colloidal condition, and usually containing both free silver nitrate and an organic acid. On exposure to light, the chloride is converted into the so-called photo-chloride, having a purple or reddish color, the photo-chloride apparently consisting of an adsorption compound of silver chloride and silver, the composition varying according to the conditions of production. After the paper has been printed, the color of deposit is modified by immersion in a bath containing a gold or platinum salt associated with a weak reducer, so that metallic gold or platinum is precipitated, and the unused silver chloride is then removed by solution in thiosulphate, which only attacks the photo-chloride to a very small extent. The chief difference between emulsions for development papers and those for plates, apart from the fact that paper emulsions are of much lower sensitiveness and consequently finer grain, lies in the fact that as the image is to be observed by reflected light, it is necessary that as far as possible it should be kept on the surface of the paper, and to this end the emulsion used has a larger proportion of silver to gelatin, the coating being thin. The color of the image obtained is naturally dependent upon the size of the grain, and if warm tones are required, developers can be used by which the silver is deposited in a very finely divided state almost approaching to colloidal division. By the admixture of such fine grain silver with larger grains, various tones can be obtained upon development papers.

FACTORY ORGANIZATION.

The typical organization of a photographic factory is similar to that of most chemical factories, the raw materials going through a progressive series of processes, and the factory costs being most easily estimated upon a process costs system taking a definite area of the product as the unit charge, and the work done in each section progressively, so that the total gives the cost of the product at the stock room.

Taking as typical of the industry the production of photographic plates, the processes are as follows: Cleaning the glass; Making the emulsion; Coating the emulsion upon the glass; Drying the plates; Cutting the plates to the required sizes; Examining the plates and packing them in paper; Packing the plates in boxes and labelling, the plates being then dispatched to the stock room.

The factory is divided into: Glass stock and cleaning rooms; Emulsion making and stock room; Coating room; Drying room; Cutting room; Packing room; Boxing room; Plate stock.

A paper factory will be similarly organized, except that paper does nor require cleaning; if any preliminary process is necessary the paper is surfaced with barium sulphate, but as far as I know, baryta coating is only done in one factory in this country. The paper is also automatically dried by the machine on which it is coated. The paper after passing through the trough containing the emulsion, travels over a cold roller to set the gelatin, and then it is hung up in loops in a long drying chamber, through which it slowly travels, emerging dry at the end of about 2½ hours from the time at which it was coated, and being rolled direct and taken to the cutting rooms. Surface coated papers without gelatin, such as platinum papers, are dried almost instantaneously on a

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short machine by hot air, and do not require the elaborate hanging and slow drying arrangements necessary for gelatin coated papers.

Photographic glass is the specially selected best quality of thin sheet glass, made in a works which prepares sheet glass for all purposes. Even in the best works, only about one-quarter of the sheets prepared are fit for photographic use, the remainder being used for windows, etc. The best photographic glass comes at present from Belgium, although good glass is also made in England, and the cost is about 5 cents per square foot. The glass is supplied cut to sizes which can be at once cut to the sizes used by photographers; the smallest size coated being generally the English whole plate, or 8½×6½ inches, which cuts into four quarter plates. The glass arrives at the works packed in straw in boxes holding usually about two gross sheets, and it is left in these boxes in the glass store until it is required for use, when it is unpacked and transferred to the glass-cleaning room.

In the early days of the industry the glass was cleaned by hand, being rubbed over with a mixture of methylated spirit and whiting, which was then washed off and the glass polished. Nowadays, however, the glass is cleaned by automatic machinery into which it is fed. The glass plate is received between two rubber covered rollers which push it forward between rapidly rotating brushes, the glass first passing between two metal tubes which spray a strong solution of soda and water on both sides. As it passes through the rollers the brushes, of which there are two or more pairs, remove all dirt from the surfaces; it is then passed through more sprays and brushes with clean water running over it, and emerges at the end of the machine perfectly clean and ready for the next process. This consists of the coating of the glass with a substratum, usually a weak solution of gelatin containing chrome alum, by means of which the emulsion is made to adhere to the glass and "frilling" is prevented. After coating with the substratum, which may be done either by the machine or by hand, the glass is dried either by passing through a long, heated box on the cleaning machine, or by transferring it to a heated oven. Each sheet is then examined for defects, and if passed, packed in a box and transferred to the coating room.

The emulsion is made, as has already been explained, by adding a concentrated solution of silver nitrate to a bromide solution containing gelatin. Negative emulsions also usually contain a small amount of iodide, a percentage of potassium iodide being introduced into the gelatin solution, while diapositive and "gas light" paper emulsions consist chiefly of silver chloride, only a small proportion of the silver salt being in the form of bromide. After the emulsion has been mixed it must be treated in order to increase its sensitiveness or "ripen" it. This can be done either by maintaining the emulsion at a high temperature for a considerable time, or by digesting at a lower temperature in the presence of ammonia. Both methods have advantages, the choice between them depending on the use for which the plates are intended, and on the experience of the emulsion maker.

After ripening, the emulsion is cooled by means of ice and set to a firm, hard jelly, and then cut into thin shreds for washing, the washing being necessary to remove the potassium nitrate produced in the reaction. The emulsion is cut up by forcing it by pressure through a metal plate containing a number of small holes, so that it emerges in thin shreds. The press in a factory is usually a hydraulic one. After the shreds have been washed, the emulsion is melted and is then ready for coating.

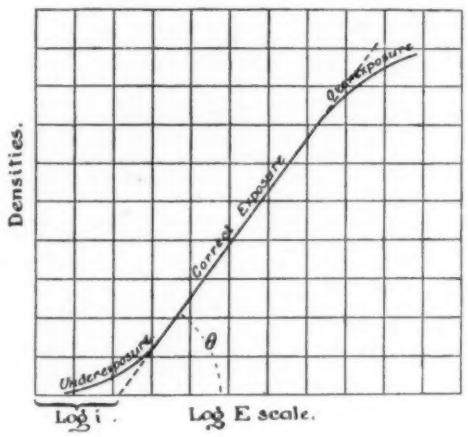
For about ten years after the manufacture of gelatin dry plates was commenced the glass was coated by hand, each sheet of glass being covered with an even layer of emulsion, usually poured from a teapot, and then laid on a level plate to set; but in all modern factories the coating is done by means of a special machine. There are several forms of coating machines, but one of the simplest is that invented by Dr. Smith of Zurich, which has been generally adopted in Germany and in several works in England. In this machine the plates are carried chiefly by means of felt bands. The glass is first laid on a dry band, which carries it under the weir. Above the weir is a barrel containing the emulsion which flows down a tube on to the weir, where it spreads out into a thin sheet which then flows down on to the plates, which are carried through under the weir by means of felt-covered rollers. The plates are then carried forward separated from each other by a roller moving at a slightly faster rate, and carried on to a long band of felt, the under side of which travels in a tank full of iced water. In traveling down this long cold band the emulsion sets on the glass, and at the other end the coated plates are transferred to a dry band, which removes the superfluous moisture from the backs, and are then placed in racks and taken to the drying rooms, where they are slowly and evenly dried, the process lasting about twelve hours. When dried, the plates are stacked in boxes and taken to the cutting and packing rooms.

The cutting can be done by hand with a diamond, using pieces of wood of accurate widths as gages, but it is more usually done on a more or less complicated machine. One of the best known cutting machines is the Munro Cutter. In the table of this machine are four jaws which open automatically and close on the plate when it is laid on the table, centering it and at the same time holding it fast while two diamonds running at right angles to each other slide over the back. The plate is then lifted off the table and breaks accurately into quarters. It is most interesting to watch one of these machines at work cutting up plates at an enormous rate and yet with certainty and accuracy.

The cut plates are now examined for defects by red light and then packed in fours in paper and the three fours packed again in paper and placed in the box in which they are to be sold.

TESTING METHODS.

Since the products of the photographic industry are essentially materials which are sensitive to light, it is clear that chemical analysis will not be a satisfactory method of testing the products, and in practice they have always been tested in relation to the actual purpose for which they are to be used. In the early days of the industry it was customary to have attached to each factory a studio, in which an operator tested the plates by taking a portrait, usually of himself, and, either allowing for variations in the daylight and atmospheric conditions, or exposing together with a standard plate, judged as to whether each successive batch of plates was sufficiently good to be issued. While this method of testing has been almost entirely abandoned for sensitive plates and films, papers are still tested in a similar manner, and I am informed by the manager of a most important photographic paper factory who is a man of the highest scientific attainments, that he does not consider that any photometric test has yet been devised by which so small a difference in the quality of the paper can be detected, as by a skilled printer used to the paper, and printing by a negative to which he is accustomed. If this be so, it would seem to suggest that much work is still necessary for the perfection of the photometric methods which can be applied to paper, and indeed, so far as I know, very little work has been done on the subject.



The earlier and cruder methods of testing plates have, however, been almost completely abandoned. The first change came when Warnerke introduced his sensitometer as early as 1881, and for many years all factories used some form or other of sensitometer of the Warnerke type for their routine testing. The Warnerke instrument consists of a graded series of densities, with a number printed on the middle of each, and the sensitiveness of the emulsion is estimated as being the last number which can be read after development and fixation. This method has the very great advantage of speed in working, and if used with really constant light, it should be still of great use to the practical emulsion maker for such a purpose as roughly testing his emulsion to see whether it is good enough to coat, or for checking batches against one another to commence packing before a complete laboratory trial can be made.

In 1890, Hurter and Driffield introduced their famous system of sensitometry, in which a plate is exposed for a number of varying times to a standard light source, and after development the mass of silver corresponding to each exposure is determined photometrically, and the relation between the amounts so obtained, which they called the density, and the logarithm of the exposure is plotted on a curve (see diagram). They showed this curve to be analyzable into three sections: the first, where the rate of increase of density steadily increases, termed the under-exposed portion of the curve; the second, where the increase of density is proportional to the logarithmic exposure, the period of correct exposure; and the third, where the density increases less rapidly than the logarithmic exposure, the period of over-exposure. They showed that for a considerable variation of development, the point at which the straight line portion of this curve meets the exposure axis is independent of the time of development, or of the composition of the developer, provided that the developer does not contain free potassium bromide; and this point they took as representing a fixed point, the position of which was proportional to the sensitiveness of the plate. The slope of the curve is dependent upon the time of development, becoming steeper as development is increased, and it can be shown that the relation between the slope of this line and the duration of development follows an exponential function which can be defined by two constants, one giving the maximum contrast to which the plate can attain, and the other being a velocity constant dependent on the composition of the developer, the temperature, and the nature of the plate. In modern photographic factories some form of this Hurter and Driffield testing system is generally adopted as the control of the emulsions, the instruments originally used having been superseded by others capable of more rapid work and of superior accuracy, while the candle originally used by Hurter and Driffield has been replaced by a more modern standard light source, such as the pentane lamp, and acetylene standard burner, or an electric glow lamp with potentiometer control. Different factories at present differ very widely in the speeds which they assign to their products by this means of testing plates, and apart from the tendency to exaggeration, which commercial interests may sometimes introduce, there is no doubt that the photographic industry is, at the present time, sorely in need of a definite standard light source. Two light sources which are photometrically equal to the eye may be of different photographic value, and there is, at the present time, nothing which is in any sense a standard photographic candle. It is impossible here to deal with the conditions which such a standard must fulfill, or with possible methods of approaching it; but there is no doubt that one of the great needs of the industry as a whole is the adoption of a uniform standard in its testing methods.

The Age of the Earth and the Length of Geological Periods

THE geologist talks somewhat glibly of different epochs which occurred in the earth's history, and which are known to have occurred in a certain historic order. He is careful, however, to warn us that of the absolute length of these periods in years he is able to tell us very little. Nevertheless, attempts have been made to make this estimate, which, of course, is of the highest possible interest.

At a recent meeting of the French Astronomical Society, Mr. J. Bosler gave a brief review, published in *Cosmos*, of the work done in this direction. The first estimate that he makes is based on a calculation relating to the rate at which the sun is giving out heat. If we assume that the sun's heat is derived from the energy of its contraction under the action of gravitation we arrive at the conclusion that this gravitational energy can have furnished at most twenty million years of such radiation as the sun is giving out at the present time. This, then, of course, also limits the age of the earth to a figure of the same order. This estimate is, in the present state of our knowledge, worth very little, for there is every reason to suppose that the sun's energy is supplemented in some measure by radio-active processes, although just what part they may play is very uncertain.

A more strikingly geological method of estimate is based upon the measurement of the thickness of geological strata. The sea at the present time deposits material at the rate of about 10 centimeters. (2½ inches) per century. Since the total thickness of sedimentary deposits amounts to 80 kilometers (50 miles), the total length of geological periods would correspond to about eighty million years.

Prof. Joly of Dublin has attempted an estimate based on the salinity of sea water. Rain water absorbed salt out of the rocks of the continents. The percentage of salt in the fresh water discharged into the sea has been observed, and it is calculated that one hundred million years would be required to bring to the sea the salt now contained therein, which represents a layer of 122 meters (293 feet) of thickness of salt covering all the continents.

Other recent estimates are based on our knowledge of radio-active phenomena. Rutherford and Strutt have examined the percentage of gases contained in radio-active rocks of different geological periods. Radium, uranium, and the other radio-active substances undergo transformation, giving rise to helium, of which a certain portion is retained in the rock, and the percentage of helium, as compared with the amount of radio-active metal present, increases with the age of the rock. An estimate can thus be obtained, which, however, presents merely an inferior limit, since gaseous helium has escaped by diffusion. However, taking these estimates for what they are worth, a rock of the oligocene period was estimated at eight million years; an eocene rock at thirty million years; a sample from a carboniferous deposit at one hundred and fifty million years; and lastly an archæan specimen was found to be seven hundred and ten million years old. Only a roughly qualitative importance can, of course, be attached to these estimates. Nevertheless, they seem to agree at least to this extent, that by all the different methods employed, they lead us to the conclusion that the age of the earth is hundreds of millions of years.

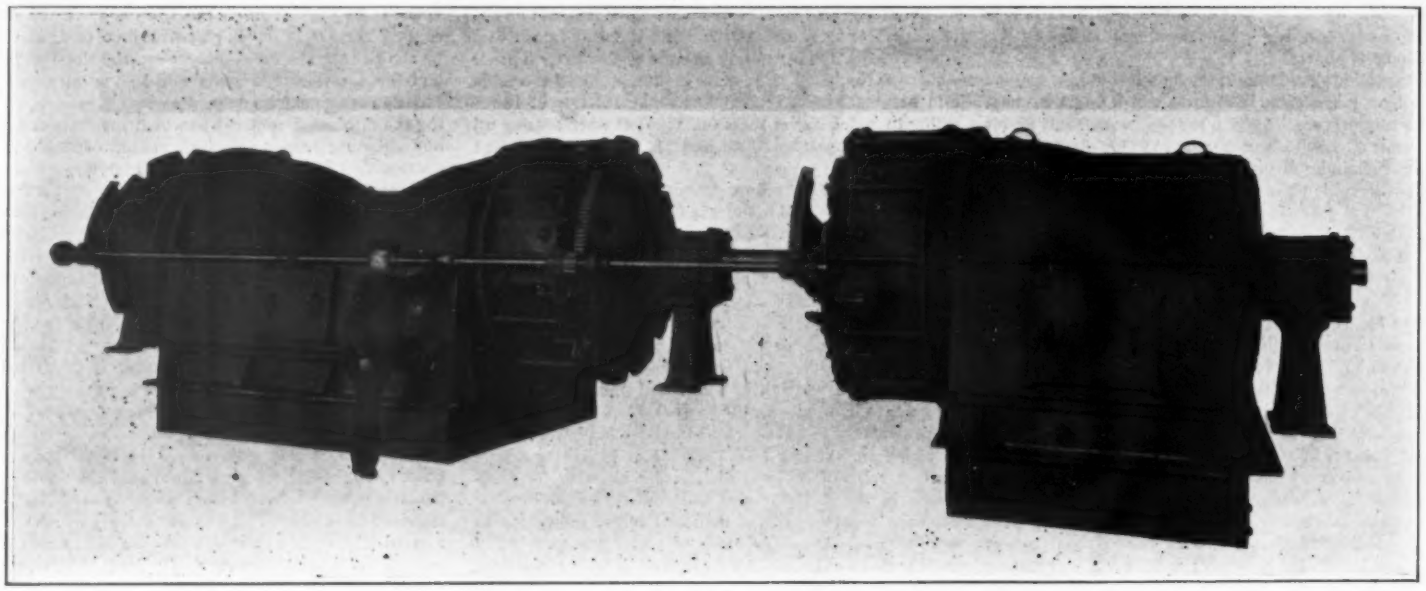


Fig. 1.—Three Draft-chest Turbines Mounted Upon a Common Shaft.

Modern Hydraulic Turbine Practice

Illustrations of Some of the New Types

Electric generators, pumps and other machinery are driven by hydraulic turbines by direct coupling, by gearing and by belting, the form of transmission depending upon the head, speed of turbines and devices driven as well as hydraulic and other local conditions.

The Rock Hill hydro-electric power plant of Charlotte, N. C., has recently installed eight large electric generating units having a capacity of about 10,000 horse-power, all of which are rope-driven from the water wheels as indicated in the accompanying illustration (Fig. 2). The original installation at this station consisted of four units of 750 kilowatts each, driven by turbines of 1,000 horse-power each, operating at a speed of 110 revolutions per minute, the dynamos being driven at an increased speed of 360 revolutions per minute by the rope-driven mechanism.

Four larger units were then installed, consisting of 900 kilowatt generators, driven by turbines of 1,200 to 1,500 horse-power capacity, each complete drive being designed for 1,800 horse-power, corresponding to an overload supply of 50 per cent for the electric generator. These electric machines supply a three-phase alternating current at a pressure of 11,200 volts for light and power service.

This power station had a total rated capacity of 6,600 kilowatts and was so arranged that the electric generators were elevated above the level of the dam crest, away from the moisture of the water wheel pit.

The driving sheaves are 14 feet 3 inches in diameter, built double and grooved for twin 17-rap drives of 1½-inch rope. It will be seen from the accompanying illustrations that the driving sheaves are mounted directly on the extended shafts of the horizontal turbine water wheels, the tension carriages rolling on an inclined track

Fig. 2.—Eight Hydro-electric Generators of 10,000 Horse-power Aggregate Capacity.

with the slack delivered to them over winders as indicated in the foreground in illustration (Fig. 2). It is most interesting to note that the rope drive is of great value in the operation of alternating current generators in parallel, as many difficulties have arisen in direct-connected steam engine-driven plants where variation above and below normal speed in each revolution, of even the most carefully governed steam prime movers, have caused much trouble. It is hard to attain and maintain exact synchronism of a number of electrical generators when engine-driven or direct-connected to hydraulic turbines, but it is stated that the perplexing problem of parallel operation is most satisfactorily solved when the alternators are rope drive and the hydraulic prime movers are regulated within reasonable limits.

The reason for this is that the elasticity of the rope drive provides for absorption of all slight periodic fluctuations of speed above and below normal, steadying the motion and enabling the generators to continue in perfect step with each other.

The largest percentage of hydro-electric plants in Europe as well as in America are direct-connected installations. One of our front page engravings shows a Swiss turbine of 3,200 horse-power capacity, built at Zurich by Escher, Wyss & Co., and operating at a speed of 400 revolutions per minute under a head of 205 feet at the Kanderwerk hydro-electric plant, the water consumption being 1,000 gallons per second at full load.

The three Escher-Wyss turbines noted in the other illustration work under a head of 99 feet using 200 gallons of water per second and develop 320 horse-power each, operating at a speed of 500 revolutions per minute.

The accompanying illustrations (Figs. 1 and 4) show turbines of the draft chest or open flume type, in which three turbines are mounted upon a horizontal shaft—a pair of turbines on a draft chest and a single turbine on a quarter-turn elbow. The draft chests are made of cast iron with removable cover and the feature of special interest in this particular installation is in the method of taking care of the end thrust on the single

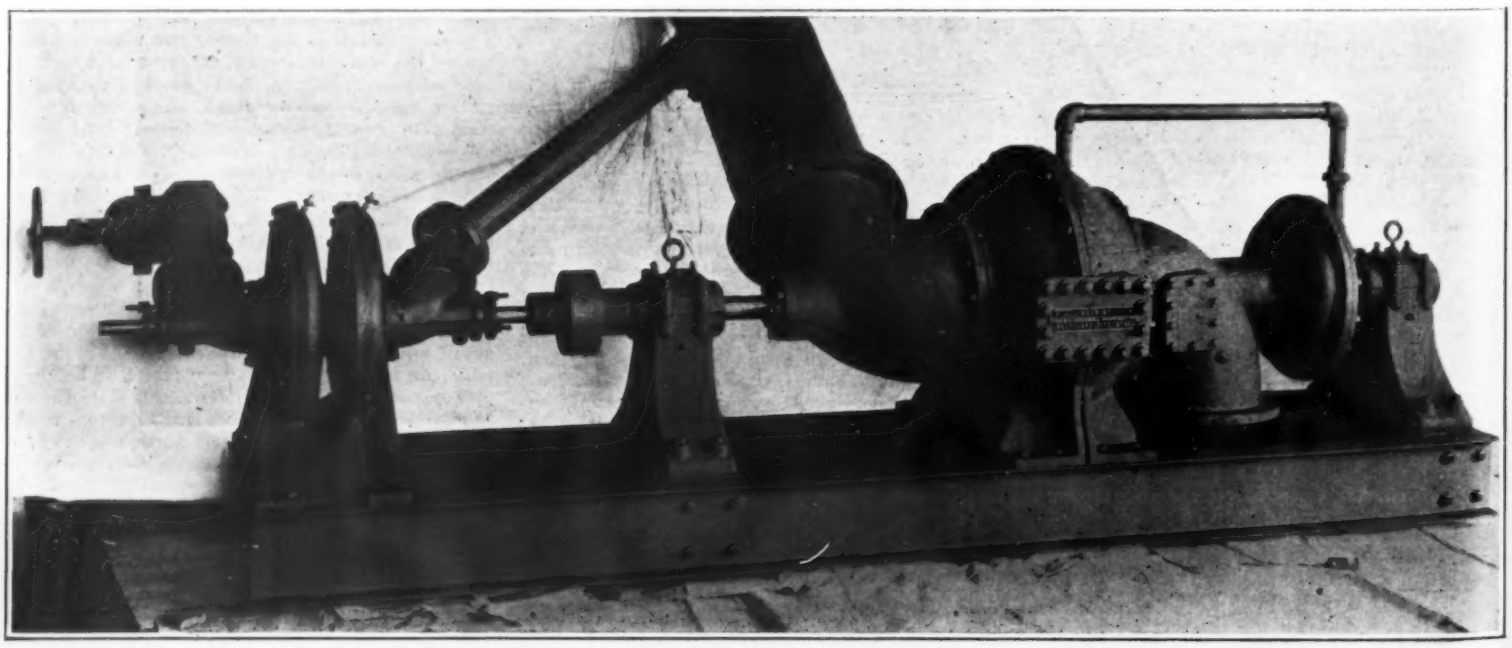


Fig. 3.—Horizontal-type Turbine for Driving Small Centifrugal Pumps.

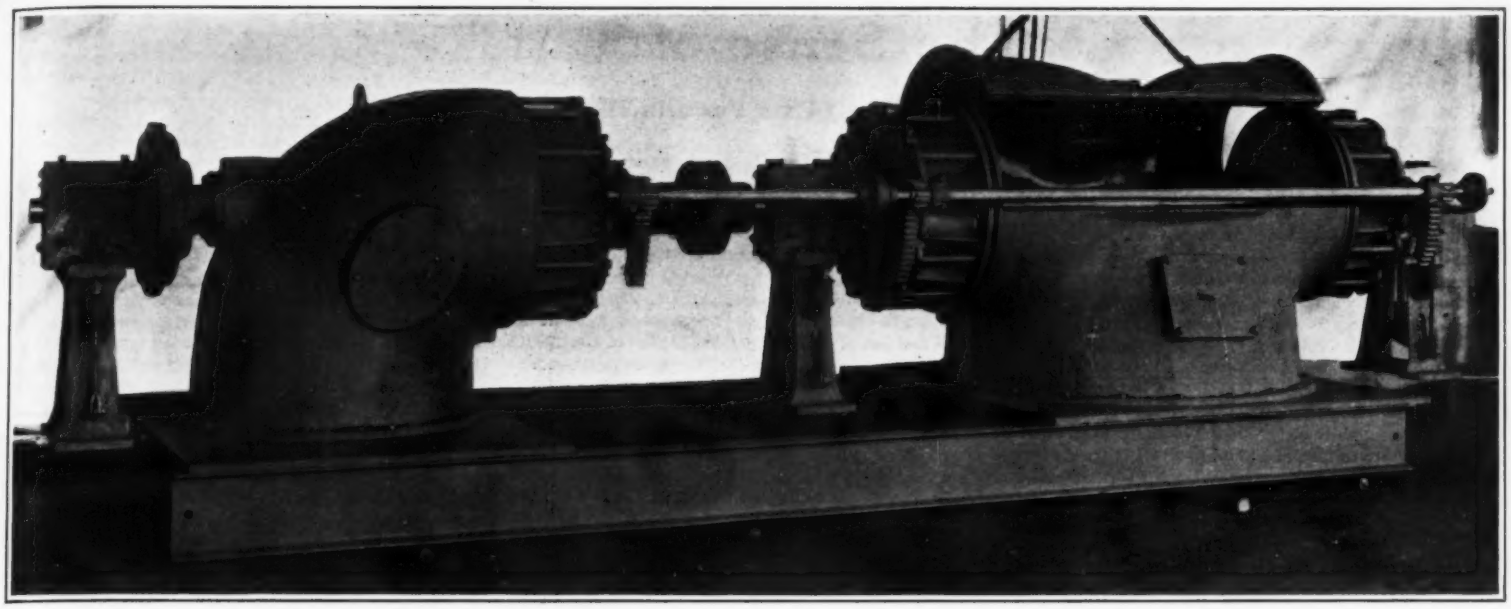


Fig. 4.—A Pair of Turbines on a Draft Chest and a Single Turbine on a Quarter-turn Elbow, All on One Shaft.

or end turbine, to which is attached a special water cushion.

This is an automatic device which eliminates the end thrust on the turbine shaft, and is a device that is said to be practically frictionless and free from wear With a water cushion it is possible to dispense with the use of all mechanical thrust bearings, or wooden thrust blocks as commonly used.

The journal boxes used on this type, which necessarily must be placed under water, are so designed that they are adjustable without letting the water out of the penstock, or without having to enter the same to line up the turbine shafting proper; and it is claimed that this type of journal box is a most valuable feature on installations where the above type of turbines are employed, as it permits of the absolute and proper alignment of water wheel shafting at any time. The working parts on the turbine gate mechanism are made of phosphor bronze, insuring the long life of these parts.

The illustrations (Figs. 5 and 6) show two applications of high head turbines for belt transmission and for driving generators direct or any other types of machinery. These units are adaptable to heads ranging as high as 350 feet and are self-contained upon steel frames.

It is true that horizontal turbines on a draft chest set in an open flume will develop a good efficiency, but it does not follow that the same turbines placed on a draft chest inclosed in a steel casing will give the same efficiency. A pair of turbines can be placed in an open flume, or even a long line of them, and give good results, for the reason that there is ample room for the water to enter each turbine without commotion or loss from counter-currents and eddies, which is not the case where the same turbines and draft chest are placed in a closed steel flume or penstock. Therefore, it is impossible to get as good an efficiency from incased turbines of this type as it is from turbines placed in open penstock with ample room on every side.

It is true that the efficiency of any turbine depends largely upon the manner in which it is installed, also the manner in which the gates deliver the water to the turbine runner. In placing a turbine in the ordinary type of steel casing with a side inlet it is impossible to get the efficiency obtainable from the same turbine placed in a casing where the water enters parallel with the shaft. Where the water enters the turbine from the side or at right angles to the shaft it will be found that the water enters the gates on one side, while on the other side there is a counter-current, which lessens the efficiency. The water should enter the turbine runner without commotion and for this reason it is claimed that Scroll type is the most efficient, as the velocity of the water is not lessened until it reaches the runner and enters all the gates of the turbine at the same velocity and without any commotion whatever.

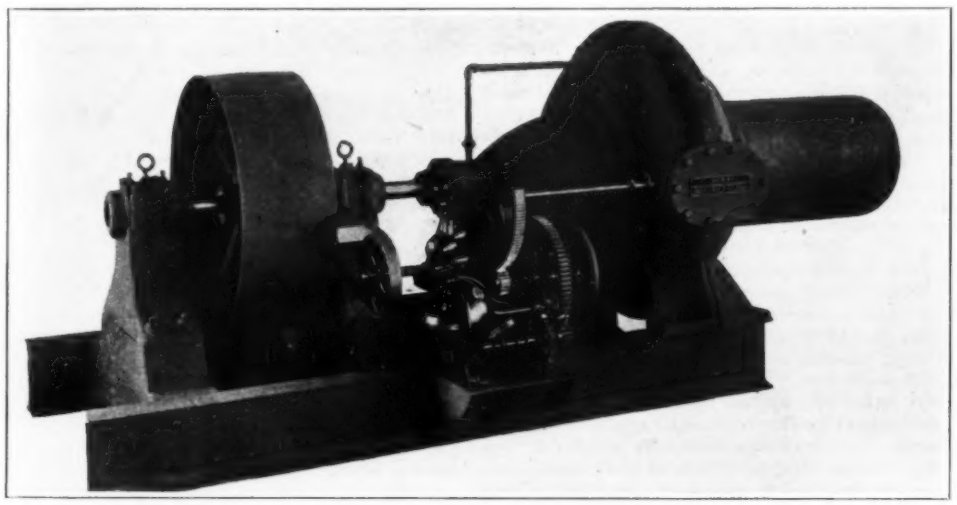


Fig. 5.—High-head Turbine for Belt-transmission.

Turbines are largely used for driving centrifugal pumps for irrigation purposes, the power being obtained from turbines placed under low heads, and in order to obtain sufficient speed for pumps, either bevel or spur gear is used. The frictional loss of power when bevel gearing is used is great, in fact there is a loss of from 20 to 30 per cent of the actual power given by the turbine, the loss being governed largely by the ratio of the gearing used, and in no event should the ratio of the gears be greater than 3 to 1.

Hence, it is difficult to obtain sufficient speed under low heads to drive a pump, without using a large diameter pump, which is expensive, to say nothing of the frictional loss of power and the wear of the bevel gears. On the other hand, if spur gearing is used, the frictional loss is not over one half as great and the life of a spur gear over a bevel gear is fully double as great. It is a difficult matter to keep bevel gears (Fig. 5) in perfect pitch owing to the fact that the least wear on the turbine step lowers the gear and throws it out of pitch, which is not the case where spur gears are used.

Some engineers claim that the coming generator of all hydro-electric plants is of the vertical or "umbrella" type, especially for low and medium heads. Under low heads at least 30 per cent of the water used is wasted when a standard horizontal generator is used and the power transmitted through bevel gearing. If spur gearing is used a much higher speed can be obtained and the cost of generator is thereby greatly reduced since it is impossible to obtain as high speed under the same conditions with bevel gears as it is with spur gears. With a spur gear-driven generator there is perfectly smooth running without vibration, the pitch lines always being together as there is no dead weight to be carried on the journals. The journals are, in fact, used merely to keep the gears in proper position and will wear indefinitely.

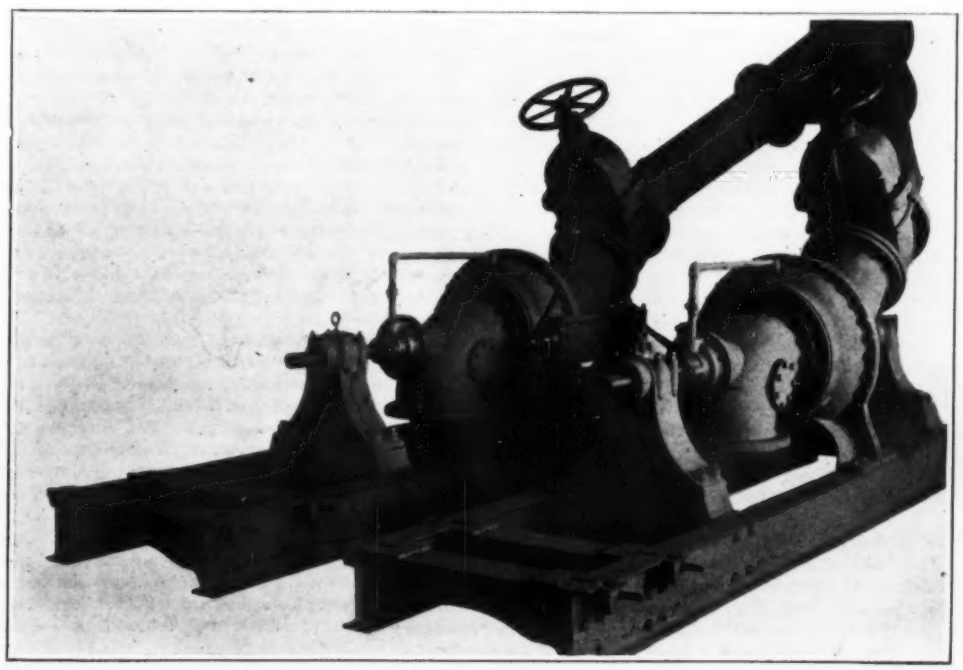


Fig. 6.—This Turbine is Adaptable to Heads Ranging Up to 350 Feet.

The Sense of Taste*

Some of Its Peculiarities

By Dr. R. Foerster

The sense of taste is evoked by a stimulation of the ends of the nerves of taste in the cavity of the mouth.

The development of the region of taste is quite different in different persons. The nerves of taste are distributed chiefly on the sides, point and the greater part of the rear upper portion of the tongue; further, over a part of the soft palate, particularly the lower border (but not the uvula), the rear of the palate wing, a part of the epiglottis, and even the interior of the larynx. In the child the sense of taste is also located in a part of the membrane of the cheek, the hard palate and the entire upper surface of the tongue.

With age the faculty of taste becomes less extended through deadening of the nerve endings, and near the close of life ceases altogether. Under the same conditions old people, therefore, taste much less effectively than younger people.

While the individual differences in respect of the sense of taste remind us of corresponding differences in the sense of smell, the two senses differ in one important respect. In many persons the sense of smell is wanting from birth, while the sense of taste has never been found to be absent. Even a new-born child, which in consequence of insufficient development had no brain, still had a sense of taste, because its facial expression altered when substances of different taste were given to it. The fact that the lack of a sense of taste is never absent at birth shows of what importance the sense of taste is for the existence of man. While the sense of smell is of importance in the preliminary selection of food the sense of taste is the final arbiter.

It appears that the sense of taste is controlled by nerves which run different courses. One of these nerves runs through the ear. In operations and in inflammations of the ear the sense of taste on the corresponding side may suffer a reduction.

In an adult a pleasant taste provokes an increased secretion of saliva, which is further promoted by a chewing movement. Burning tastes also promote a secretion of saliva. In the first case the secretion is for the purpose of giving the food a preliminary preparation, and in the second case the secretion is for the purpose of diluting the stimulating substance and is generally connected with a tendency to spit. In the case of a child a sweet taste stimulates a sucking motion, while bitter, sour and salty flavors counteract such motion. In a similar manner there has been observed an influence on the breathing of the child, as has also been observed in adults, even in sleep; in fact, even in those sleeplike conditions of hypnotism, which under certain circumstances may last for weeks, and in the case of those suffering from mental diseases.

In the tongue the nerves of taste end in the so-called papillæ of taste, which consists of supporting cells with slender taste cells. The end organs of the nerves are very fine fibers which twine about the taste cells. Around the papillæ is a ditchlike depression which takes up the flavoring substance and gives it an opportunity to act for some little time on the nerve, and thus make its presence felt. This provision seems to be an essential one, otherwise stimulating substances would be quickly washed away by the secretion of saliva. On the other hand, we can readily understand why the presence of these depressions makes it necessary in tasting several substances, one after another, to wash out the mouth thoroughly with vigorous movements of the tongue in order to remove the remains of one substance before trying to perceive the taste of the succeeding one.

In the sense of smell the conditions are different. In this case the presence of one odorous substance can be detected, notwithstanding the previous presence of another, so that it is possible to detect the presence of several odors in a mixture.

Only solutions are capable of being tasted. Even gases require to be dissolved in the mouth-liquids before being perceived by the sense of taste.

As to qualities of taste, we generally distinguish between sweet, sour, bitter and salty. To these we may add alkaline and metallic. Some objection has been made to considering salty and sour as qualities of taste, because they are burning or pungent. According to this view the sense of pungency is due to the sense of touch of the tongue, which in fact often co-operates with the sense of taste. Against this view it is correctly objected that even sweets, when in strong concentration, have a certain burning effect.

In defining the metallic taste, this is said to be a mixture of sweet and sour. The oily, aromatic, pungent and astringent effects of taste are effects produced jointly upon the sense of smell, touch and temperature. A sour taste is often a component of tastes which are called astringent. Children frequently confuse sour and salty, both being called sour by them.

The sense of sweetness is especially perceived by the upper part of the tongue, the sense of bitterness chiefly by the rear part. Of the taste papillæ, which, as noted above, are the terminals of the nerves of taste, some detect all and others only one particular kind of taste. Out of 125 papillæ 27 do not react. The remaining 98 behave as follows:

98 react to tartaric acid
79 react to sugar
71 react to quinine
12 react only with tartaric acid
3 react only with sugar
0 react only with quinine

For perceiving these various tastes the following quantities were necessary:

Of sugar	3 to 58 milligrammes
Of salt	1 to 36 milligrammes
Of sulphuric acid	0.4 milligramme
Of quinine hydrochloride	0.04 milligramme
Of strychnine sulphate	0.005 milligramme

A salty taste is the one most quickly perceived, then sweet, then sour, and bitter the slowest of all. In order to perceive the different tastes by means of the end of the tongue the following times are necessary:

	Minimum:	Maximum:
	in seconds	
Salty	0.25	0.72
Sweet	0.30	0.85
Sour	0.64	0.70
Bitter	2.00	7.00

Recently the possibility of perceiving taste in the stomach has been disputed. To 15 persons suffering with stomach troubles, *spiritus aromaticus* (dilute oil cloves) was given. Among 80 experiments 67 cases were recorded of the perception of a feeling of pungency or warmth in the region of the stomach. In 26 cases the sensations varied with a change of condition of the body. Undoubtedly, therefore, the stomach has a sense of feeling in this respect. Hydrochloric acid in a concentration of 0.4 to 0.5 per cent had no effect in the empty stomach. Alcohol causes a light feeling of pungency in the stomach, which is more pronounced in the œsophagus.

Investigations on the relation of chemical composition to the production of the sense of taste have not been very fruitful, as has been the case with similar investigations on the sense of smell. There is no regular connection between constitution and action on the sensitory nerves. Nature does not always give warning signals, and there exist poisonous gases which are not recognized by their odor. The same condition exists with the sense of taste. Not all poisons produce vomiting: corrosive sublimate corrodes without affecting the sense of taste. As a general rule the sense of taste is more sensitive to crystalloids than to colloids, and as a general rule it has been found that among the alkaloids bitter substances and among the carbohydrates sweet substances predominate. Nevertheless, there is a whole series of other substances which have a sweet taste, such as chloroform and other like substances, as saccharine, also sugar of lead, salts of beryllium, etc.

The term acid, which originally designated a quality of taste, has now been extended to include substances which do not taste sour; while on the other hand, the sense of sourness is evoked by a number of substances that are not acids. In certain cases there is an apparent connection between constitution and taste, as in the case of halogen compounds and the light metals lithium, potassium, sodium, rhubidium. In these substances the intensity of the taste of equi-molecular substances is proportional to the molecular weight. Equi-molecular solutions of mineral acids have different degrees of action on the tongue; sulphuric acid is more acid in taste than phosphoric acid.

The sense of taste does not appear to be affected by bodily weariness, in contrast with what happens to the sense of smell. On the other hand, the sense of taste is subject to marked contrasts. Metallic salts confuse taste sensibility to a marked degree. For example: after rinsing the mouth with a solution of copper sulphate, or potassium permanganate, cigar smoke will taste sweet. Similarly, after rinsing the mouth with potassium chlorate, or dilute sulphuric acid, but not with other acids, pure water will have a sweet taste. After drinking a strongly sweetened beverage a sour drink will have a strikingly sour taste. This seems very peculiar because experimental tests have shown that under such circumstances the limit of sensitiveness for a sour taste was increased, that is, after the nerves of taste had been stimulated by sweets, the sensibility to acids was decreased. One would therefore expect that a sour drink following a sweet one would make less of an impression. In this case we doubtless have to do with a disappointment in expectation, which makes the contrary feeling appear to be of a paradoxical nature. The same seems to be the case in many instances with our perception of stale or flat taste. Many things taste flat when a good taste is expected and not found. A particularly interesting contrast action is the following:

A 0.1 per cent solution of salt and a dilute solution of quinine, which both have no more taste than pure water, always causes a sugar solution taken after them to taste sweeter than usual. Mixed tastes in dilute solution sometimes compensate or neutralize one another by a mixture; dilute sugar and salt solutions act oppositely to one another and produce a sort of mixed flat taste. In the case of stronger solutions there seems to be a contest between the two tastes; first one and then the other will predominate. In a solution which contains both sweet and bitter the different ingredients will be perceived at different points on the tongue and at different times. The production of a proper mixed taste is therefore a difficult matter. The simultaneous employment of sweetening agents in medicine is often practiced by physicians because the sweet ingredient will lead the attention of the patient to the more pleasant taste, thereby withdrawing if from the bitter and evil-tasting ingredients of the medicine.

As above stated, there are certain normal changes in the sense of taste, consisting in a progressive decrease of sensitiveness, which is especially rapid in the passage from childhood to adolescence, and then proceeds more gradually as age increases. But there are other peculiarities in the sense of taste which should be noted. The child finds highly concentrated sweets pleasant to the taste. All other very concentrated tastes he perceives as unpleasant. Only as the individual grows older does he place any value on the qualities of bitter, sour and salty.

As to whether there exists a difference between men and women as regards the sense of taste is difficult to decide, since habit plays a rôle that is difficult to calculate. Men who do not smoke and who, for other reasons, are more inclined toward sweet substances, appear to have a distaste for bitter substances, but here habit is of vast importance. For example, many Germans cannot bear the taste of absinthe, which is much more favorably regarded in France. Pathological disturbances of taste occur in certain cases, as in operations on the middle ear and in hysteria. In these cases the perception of sour is the one most frequently destroyed, while the taste for sweet is less frequently affected.

Sour is often confused with bitter. In one case a woman of ninety years sweetened all foods, without exception, because she was supersensitive to bitter tastes. In contrast to this case there are old people, whose sense of taste has been impaired, who eat repulsive things. In a case of tabes the remarkable fact was observed that sweet was immediately perceived by the end of the tongue, whereas the remaining qualities were perceived much later, if at all. The ability of the soft palate to detect these qualities was exactly reversed. From this case it has been argued that every taste quality has its own nerve system.

The most frequent cause of the destruction of taste in normal persons is through catarrh of the mucous membrane, the sense of smell being affected at the same time.

It remains to note the action of certain chemical substances on the sense of taste: Gymnemic acid suspends the ability to perceive sweet and bitter; for example, for hours after introducing this acid into the mouth sugar and quinine are regarded as tasteless. The presence of this substance, however, does not affect the perception of sour and salty. Cocaine, eucaine and Erioditon glutinosum suspend first the taste for bitter and later the other qualities.

For the production of the highest possible degree of sensitiveness of taste the following points must be especially observed:

1. The quantity of a material to be tasted must be sufficient in order to bring it into contact with as many taste papillæ as possible.

2. The flavoring substance must be actually brought into contact with the area covered by the nerves of taste; that is, in most cases a vigorous motion of the tongue is necessary to perceive the taste.

3. The time of action must be sufficiently prolonged.

4. The temperature must be suitable. The best temperatures for tasting are between 10 and 20 deg. Cent. (50 and 68 deg. Fahr.). Ice-cold water and water of 50 deg. Cent. (122 deg. Fahr.) within ten seconds make the tongue insensible to all qualities of taste, with the exception of sour.

* From *Wochenschrift für Brauerei*, through *Pure Products*.

5. The taste qualities are perceived with different rapidities and with different degrees of certainty. This point is to be especially regarded in the judging of a particular flavoring substance.

6. When tasting several substances in succession, the remains of one taste must be carefully removed before proceeding to another by rinsing the mouth with a vigorous motion of the tongue and in some cases by promoting an excretion of saliva; for example, by chewing breadcrusts.

7. Apparently the mental state of the taster is not without importance. Persons afflicted with mental or nervous diseases suffer a proportionate decrease in the sensitiveness of their taste organs, and this is especially true of epileptics. However, this is largely governed by practice. Ability as a taster and a good memory are often associated.

8. Taste is influenced by contrast, not only as regards contrast with material which has been previously tasted, but also as a matter of regular habit. This is largely due to impregnation of the mucous membrane with remains of substances which are often tasted; for example, smokers have a different sense of taste from that of nonsmokers.

9. The sense of taste is dependent upon the state of sensitiveness of the nervous system. Nervous persons sometimes are greatly supersensitive to taste stimulants.

10. The taster must be free from catarrh of the mucous membrane and his mouth must not be affected by circumstances which might influence the taste, such as defective teeth, ulcers and coated tongue.

11. To render a reliable decision upon a given taste it is advisable to have the test made by several different individuals.

12. Considering the very different conditions of life, not only in different nations, but in different parts of the same country and in the different strata of the population, such, for example, as the existence of the practice of chewing tobacco, it is to be expected that the judgment regarding the taste of any particular substance will be somewhat variable. Considering the different habits of taste of different persons, it is quite conceivable that a taste quality will be quite satisfactory to one people as a rule, while it will be regarded with very little favor by another people.

All commercial testing for taste will be the most satisfactory when the taster resides in the district where the goods are to be consumed and who knows exactly the life conditions of the majority of the population and of the different strata of the population.

That the sensibility of the sense of taste may be enormously increased by practice is known from the existence of wine tasters, tea tasters and a number of other professions.

The Present Status of the Diesel Engine in Europe.—II.

And a Few Reminiscences of the Pioneer Work in America

By Dr. Rudolph Diesel

(Continued from Supplement No. 1897, page 302)

I WILL now present a historical summary of the Diesel engine and will first speak of the four-stroke cycle engine. The first vertical stationary Diesel engine constructed in 1893 had the piston fitted with a piston rod and external cross head, the cylinder having no water jacket; the cam shaft was arranged very low, and the valves were actuated by means of long rods. The starting storage chamber consisted of a wrought iron pipe with riveted flanges, and there was no air supply pump, the fuel being injected directly. This engine was not destined ever to run, not even one revolution, for at the first injection of fuel—the engine being driven by transmission—there occurred a terrible explosion and the indicator went to pieces, nearly killing me. But I knew then just what I wanted to know: It was proved possible to compress pure air so highly that the fuel injected into it ignited.

I built then my second engine; it had a similar base to that shown before but it had a water jacketted cylinder and the cam shaft was placed higher up. But the most important difference from the first design was in the air supply pump for the injection of fuel, the necessity for which was only recognized after several years experimenting and without which a smokeless combustion could not be effected.

The second engine also was incapable of running, and it was always a danger to stand near it. But it gave the first indicator cards of the whole cycle in the few revolutions I could get out of it. These first two engines taken together proved the practical possibility of carrying out the combustion process which I had developed theoretically years ago, and which had been regarded impossible by the technical world of that time. I myself would never have had the patience and the courage of continuing the work after the disappointments of the two first years of experimenting had I not been supported by my unalterable beliefs in the correctness of my mathematical deductions.

The first reliable and complete Diesel engine was an 18 horse-power motor finished in 1897 at Augsburg after about four years laborious experimenting. It was a vertical engine having the piston connected to an external cross-head and worked on the four-stroke cycle.

A commission of engineers and experts came from different countries to examine the engine. One of these experts was Col. E. D. Meier, who passed a few weeks in the engine room at Augsburg, testing and trying the little engine over and over again, and cross-examining the operating engineer, and thus forming his opinion about its significance. He was one of the very first engineers to recognize its future possibilities in realizing as far as possible Carnot's ideal cycle, and economically utilizing the vast and increasing supplies of oil fuels.

Mr. Adolphus Busch of St. Louis on the point of sailing for home summoned him to Paris, and after reading his report and discussing it from all points agreed to its conclusions and arranged a meeting with me at Cologne, at which we formulated and signed a contract giving Mr. Busch the entire and complete control of all my patents. Both gentlemen have since been the faithful and tenacious pioneers of the engine in this country.

In the following year, 1898, a single cylinder engine of 20 to 25 horse-power was built at the Augsburg works. It had all the characteristic details of the experimental engine just mentioned and was the first commercial machine. This type has remained to the present time the exclusive and almost stereotyped pattern for all stationary slow speed Diesel engines, in various countries.

The only alteration which was made in the year 1901 was the abandonment of the external cross-head and adoption of a trunk piston. Vertical four-stroke cycle engines of from 10 to 250 horse-power per cylinder were constructed after this pattern, and units up to 1,000 horse-power were obtained by combining several cylinders. These engines ran at comparatively low speeds, from 160 to 200 revolutions, according to their size, and were of very heavy construction.

In Europe the Diesel engine has found extended application in the great cities, for power plants of department stores, restaurants and the like. For it has been fully recognized that the Diesel engine is the predestined engine for big centers owing to the absence of steam boilers, of smoke, coal manipulation and on account of the small space occupied, the cleanliness and the complete absence of danger. These engines are the only ones that can be installed everywhere without any special concession or permit from the city authorities.

This gives me an opportunity of speaking of the wonderfully developed buildings commonly called skyscrapers of this country, whose power plant is, as far as I know, generally a steam plant. I think that it would be a great improvement to do the mechanical service of these buildings by Diesel engines, the waste or exhaust heat of which would be sufficient to generate all the hot water necessary in the different offices and other places. The steam heating alone would have to be done by boilers, which, of course, would be fired by the same fuel as the Diesel engine and would be entirely out of commission for the summer months of the year. Such installations would not only be simpler but also much more economical in operating cost and would do entirely away with the question of smoke production in big centers.

The numerous Diesel engines which have been built in various factories and in various countries still in the main up to this day are almost an exact copy of the old experimental engine which is to-day in the German Museum at Munich. Only in America was the design simplified from the commencement by the American Diesel Engine Company, which was succeeded by the Busch-Sulzer Bros. Diesel Engine Company of St. Louis. In America these engines were built without cross-heads from the beginning, an idea which as already mentioned was followed in the year 1901 by the European works after the American engines with trunk pistons had proved successful. They were also built from the commencement with a closed base frame, and this construction as will be seen later has also been recently adopted in the European high-speed engines. Moreover, the American engines had no valves in the cylinder head, but these were placed in a chamber cast at the side of the cylinder head, which necessitated the fuel needle being placed horizontally between the suction and the exhaust valves. Finally, the Americans instead of driving the air pump for the injection of the fuel direct from the engine always set it up independently and drove it either by a small extra engine, by a transmission shaft, or by an electric motor, in the manner in which air pumps are now set up in many Diesel engine plants on board ships.

The total aggregate of Diesel engines in the United States is now about 150,000 h. p. in about 300 units.

As the central electric stations took up the Diesel engine very early, the necessity for quicker running engines arose. This need and the improvement in methods of construction and utilization of materials caused the gradual introduction of the new quicker running four-stroke cycle engines, with speeds of from 300 up to 600 revolutions. These, however, were still exclusively vertical. The main difference in construction as compared with the first type was that the bearings of the crank shaft were connected with the cylinders by means of light steel columns instead of by heavy cast iron A-shaped frames, so that the cast iron pedestal of the machine became a light crank case relieved from great strain; in addition the thickness of all the castings was diminished. By this means the weight of the engines was reduced to about one fourth to one fifth of the weight of the old types, or to about 50 kilogrammes (110 pounds) per horse-power. Four-stroke engines of this kind are now built up to about 700 horse-power and are especially suitable for driving dynamos, blowers, and centrifugal pumps, and also as auxiliary engines on board large vessels, etc.

When in the last decade, through rapid development of the French submarines, an urgent need for a reliable submarine engine was felt, these four-stroke cycle engines were further reduced in weight by using steel and brass castings, with still thinner walls, and they have also recently been fitted with reversing gear.

Small Engines.—This summary of the development of the vertical four-stroke cycle engine would not be complete without a reference to the small engine which has recently been built. For their construction, many hints have been taken from automobile engine designs.

Horizontal Stationary Engines.—After vertical engines had solely been used for about twelve years, horizontal four-stroke cycle engines were built. The first horizontal engines were practically only vertical engines laid on their sides without any independent structural innovations. Gradually, becoming accustomed to the new condition, the designers freed themselves from the tradition of the vertical engine, and some details were altered in such a way that they were more suitable for the horizontal position, and a type of engine was thus obtained which in outward appearance reminds strongly of the horizontal gas engine. The M. A. N. built such horizontal Diesel engines for very high horse-power as double-acting four-stroke cycle engines with two or four cylinders arranged tandem. The largest engine of this kind which has been built is a double-acting, four-stroke cycle tandem twin engine of 1,600 to 2,000 horse-power or 400 to 500 horse-power per cylinder, with a speed of 250 revolutions per minute; this engine works entirely on water gas tar.

Two-stroke Cycle Engines.—As I have very often stated in my publications, the Diesel principle is essentially suitable for a two-stroke cycle engine, because the scavenging is not done with a fuel air mixture, but with pure air, so that not only untimely ignitions but also fuel losses are avoided, and the scavenging can be done more effectively and with almost any quantity of air desired. To-day the two-stroke type is on a nearly equal footing with the old four-stroke cycle engine. This has been effected by working entirely on the original Diesel principle. I say "on a nearly equal footing" because the four-stroke cycle engine still has a better combustion and a more economical fuel consumption and is, above all, simpler in its method of working. It thus remains the standard perfect engine and still predominates for medium-sized stationary plants up to 500 or 600 horse-power (no exact limit can be given) wherever the highest perfection and the greatest economy are desired. On the other hand, the two-stroke cycle engine with its smaller cylinders has now come into favor for stationary plants of higher horse-power, and, as a marine engine, seems to become the standard type. Two considerably different fundamental types of two-stroke cycle engines have so far been competing. The first fundamental type is the engine made by Messrs. Sulzer Brothers, Winterthur, with separate scavenging pump. The second, the M. A. N. engine was brought out much later; in it the scavenging pump which has an annular or slop piston, is placed underneath each combustion cylinder. Both engines are single acting.

(To be continued.)

A School for Canary Birds

How Canary Birds are Scientifically Bred and Trained

By Jacques Boyer

It is said that a hundred thousand canary birds are kept in Paris apartments and that it costs $2,000 a day to supply them with chickweed alone. They also consume large quantities of lettuce, and of millet, hemp and other seeds.

Although many varieties of canary birds are sold under different trade names, all are descendants of the common gray species of the Canary Islands, which was brought to Europe in the fifteenth century. In the wild state, the plumage of this member of the *Fringillidæ*, or finch and sparrow family, is brown, mixed with gray, on the back, greenish yellow on the breast, mottled brown on the sides and nearly white on the rump. This original livery has been modified by captivity and cross breeding, so that the typical cage bird of to-day is entirely covered with feathers which are white at the base and of a bright lemon yellow color at the outer end. The outside of the wings is of the same hue, while the inside and under side are white. The twelve tail feathers are usually yellow. The middle tail feathers are shorter than the lateral ones, so that the tail is forked. The feet and the sharply pointed beak are white.

I shall not describe the twenty-nine species of canary bird which Buffon complacently enumerates, but which differ so little that they are not even distinct varieties. It is necessary, however, to mention the frizzled or Dutch canary, which is distinguished by the length and shape of its body, by its peculiar attitude and especially by the arrangement of its feathers. By careful selection and special diet three highly priced breeds have been obtained from the original Dutch variety by English, French and Belgian breeders. The Paris Dutch canary is much

Canaries in a Paris Bird Shop.

A Mother Canary and Her Nest.

The Greenfinch, a Near Relative to the Canary.

Canaries Exposed for Sale at the Paris Bird Market.

THE CANARY IS THE FAVORITE CAGE BIRD IN ALL CIVILIZED COUNTRIES.

larger than its ancestor, sometimes measuring ten inches from the tip of the beak to the end of the tail. It maintains an erect, but not stiff, posture on its perch. When it stands on the floor the tail makes an angle of 45 degrees with the body. This peculiarity is called "a perching tail." The feathers of the back are curled, or "frizzled," and a line of parting extends from the shoulders to the rump. The lateral feathers are long, soft and frizzled. They appear to point forward, instead of backward, and form two large puffs, called fins, the size of which determines the bird's market value. The plumage of the breast should be very bushy and thicker even than the fins, with a shallow depression extending along the median line of parting.

Several short, narrow pointed and brightly colored feathers extend downward at each side of the base of the tail, which is square at the end. The head is covered with feathers radiating from a common center. In comparison with these "points," which are seldom found associated in a single specimen, the coloring is of minor importance. Frizzled canaries may be yellow, white, white and green, or white and yellow, but the coloring must be vivid and harmonious. An exhibition of Dutch canaries is held annually in Paris. The finest birds often fetch prices exceeding $100.

In the north of France we find the Lille or Roubaix Dutch canary, which resembles the Parisian breed, but is smaller and more delicately formed. The Belgian Dutch canary is distinguished by the inordinate length of its neck, and by its habit of lowering its head and raising its shoulders. Hence it is often called the hump-back canary. Paris breeders often cross the canary with the green finch, but the cross is not a favorite, except with poor people, who like its hardiness and its friendliness toward other small birds kept in the same cage.

In breeding canaries, the first essential is to obtain good parents of the variety best suited for the object in view. Green and green-spotted birds bear captivity well, but make a deafening noise. Brown and dark yellow birds are delicate and not prolific, and birds with red eyes are the most delicate of all. If good singers are desired, the parents must be of pure blood and must not be placed near larks, finches or nightingales. If crested canaries are wanted, parents with very full crests should be selected.

Each bird is placed in a cage having at least two doors, so that it can be transferred to a fresh cage at any time without touching it, by placing the open doors of the two cages in contact and inserting the hand into the other end of the old cage. In this way the cages can easily be changed for cleaning or for any other purpose. The floor of the cage is covered with fine sand, which is changed every other day in summer and less frequently in winter. At pairing time, which comes about the end of March or the middle of April in France, a male and a female bird are put together in a very clean cage which contains a wicker nest lined with chopped hay, moss or cotton.

Some canary birds lay only once or twice each year, but the best known varieties produce four clutches, each of four or five eggs. As soon as each egg is laid, it is taken from the nest and replaced by an ivory egg. When the mother bird has stopped laying, the real eggs are substituted for the imitations. In this way all of the eggs are hatched at the same time. The young birds are left with their mother from twelve to fifteen days, and are then removed and fed by hand for about twenty-five days, with a mixture of boiled wheat meal, water and yolk of egg, to which boiled rape seed, almond paste and other ingredients are successively added, as the chicks increase in size. After this period the young birds are able to eat without assistance. During the following month their cages are kept supplied with a mixture of ground hemp seed, hard-boiled yolk of egg and boiled wheat meal, and also with chick weed and water. After this, their diet, like that of their parents, consists of whole hemp seed, rape seed and millet.

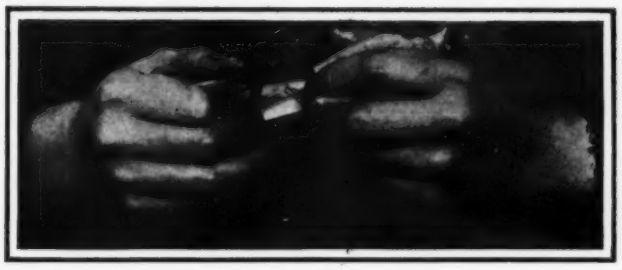
Caged birds are subject to various diseases. One of the commonest is the pip, characterized by a horny pellicle which is formed on the tongue and which prevents feeding. The treatment is very simple. It consists in pricking the pellicle with a pin, in the manner illustrated in one of the photographs, and giving lettuce seed as a febrifuge. Another photograph shows how the spurs of young canary birds are clipped, in order to prevent injury in fighting. Only half of the nail is removed, for, if trimmed too close, the bird would not be able to stand, and the remedy would be worse than the disease.

The musical training of canary birds is conducted with the aid of a bird whistle or a flageolet. A fortnight after the young bird has learned to feed itself it is put into a solitary cage where it soon begins to warble, if it is a male. The cage is then covered with white muslin and its occupant is fed on colza seed and bread soaked in water. During the first week of isolation the bird is not allowed to hear the song of any other bird, and during the second week a few notes of medium pitch are played each morning before the cage. After this, an experienced canary breeder advises covering the cage with very thick green or red serge and thus keeping the bird in darkness until it has learned a few short musical phrases.

The natural musical aptitudes of canaries vary as greatly as those of human pupils, and the time required for instruction varies accordingly, from two to six months, while some birds never learn more than a few notes. At Andreasberg and the neighboring villages of the Hartz Mountains in Germany, where the best singing canaries are trained, excellent results are obtained also by keeping several young birds together and taking care that they do not hear the chattering of gold finches, linnets or other inferior songsters. After a few months the young canaries that have shown the highest musical talent are put with a very fine singing canary and confided to his tuition for two years. The process is sometimes shortened by taking the pupil from the teacher in the first autumn, and, after ten months' rest and the next season's moult, sending him back for a few weeks to refresh his musical memory. Very good singers are produced in this way.

Canary birds have very sensitive throats and must be carefully protected from drafts, as even a slight hoarseness may result in permanent loss of voice.

A Typical French Canary.



Clipping a Canary Bird's Spurs.

An Operation for the Pip.

The Dutch or Frizzled Canary.

As its name implies, and as already stated, the canary is a native of the Canary Islands and also of Madeira and the Cape Verde. It was introduced into Europe as a cage bird in the latter part of the fifteenth or early in the sixteenth century and has now spread all over the civilized world.

In the wild state of the bird its plumage is greenish, streaked with darker shades, and the yellow, orange or red shades of the domesticated birds are entirely the result of artificial selection by man. The size of the canary, as well as its color, has been profoundly modified by domestication and some varieties are half as large again as the wild bird, which is rather more than five inches in length. In their native haunts canaries frequent the vicinity of houses, build their nests of moss, hair, grass, feathers, etc., in bushes or trees, and raise two or more broods in the season. The eggs are four or five in a set, and are pale blue, generally unspotted. The birds feed chiefly upon seeds, especially of certain grasses, but they also eat soft green leaves, buds, and occasionally insects.

Canaries are the easiest of cage birds to care for, as almost the only essentials are cleanliness, food, and water. The cage and especially the food and water vessels should be kept scrupulously clean. A bath should be provided at least once a week, and occasional freedom from the cage in a closed room is a real benefit to the bird. Care should be taken not to expose the bird to cold draughts, hence it is usually unwise to hang the cage near windows, at any rate, during wintry weather.

The principal articles of food should be canary-grass seed, hemp seed, and rape, but green leaves, such as chickweed, are necessary to maintain perfect health. Sugar is also greatly enjoyed by canaries, and is a proper food in small quantities; but acids, such as fresh apple, should be avoided. Lime is essential to the bird's welfare, and is best provided in the form of cuttle-fish bone.

Application of Aluminium Pulleys to Planers

Reducing the "Fly Wheel Action."

THE American Tool Works Company, Cincinnati, Ohio, has adopted for use on its large size planers (36-inch heavy pattern and up) an aluminium driving pulley. This style of pulley has been applied to many of the planers in this company's shop and the results have been so satisfactory that it was decided to use aluminium pulleys on the large planers instead of the regular cast-iron pulleys. It was not, however, the company's original intention to adopt aluminium pulleys as a standard construction, as they were used in an experimental way to overcome certain conditions which existed in its shops.

The aluminium pulley has many decided advantages over the cast-iron type. To begin with, it is made of a special aluminium alloy, the specific gravity of which is only about one-third that of cast iron. The weight of the cast-iron pulley formerly used on a 36-inch planer is approximately 105 pounds, while the weight of the new aluminium pulley of practically the same dimensions is only 35 pounds, the aluminium pulley weighing only one-third as much as one made of cast-iron. It is this diminution in weight which gives the aluminium pulley the advantage over the heavier one of cast iron.

Those who understand the planer and its operation are familiar with the flywheel action of the tight pulley, especially on a planer having a high countershaft speed. This feature results in the loss of considerable time owing to the over-run of the table at each end of the stroke, and to overcome this the belts must be tightened to such an extent that they soon wear out the loose pulleys. Another serious feature is the rapid deterioration of the belts, which are rapidly worn by the friction and resulting heat caused by the belt overcoming the momentum of the tight pulleys at the instant of reversal. The use of the aluminium pulley is said to entirely overcome these objectionable features.

The momentum of an aluminium alloy pulley as compared with a cast-iron pulley of the same dimensions and running at the same velocity, is in the same proportion as the difference of the specific gravity between the two metals. Therefore, the aluminium pulley will have only about one-third the momentum of a cast-iron pulley if both are running under the same conditions. The advantages of this reduced momentum are obvious: The belts do not have such a tremendous force to overcome and will therefore "pick up" more quickly, thus effectually eliminating practically all over-run of the table.

The actual efficiency of this construction is shown by the results obtained on a planning job done on 48- by 48-inch by 26-foot, quadruple head, multi-speed planer equipped with aluminium tight pulleys and driven by a 25-horse-power motor at a 40-foot cutting speed and an 80-foot return speed. The piece being planed was a table for a locomotive frame drilling machine, having a length of 26 feet 4 inches, a width of 30 inches and a depth of 30 inches. The total weight of this casting was 21,390 pounds. The length of the cutting stroke was 26 feet 10 inches and the difference between the stroke and the length of the table was 6 inches, which was necessary to permit the lifting and dropping of the L-tools. As the limit of the table travel is 27 feet, the bull-wheel was in mesh with only three teeth of the rack at the end of each stroke. Evidently this permitted practically no over-run at the ends of the stroke, as otherwise the table would have run off the bull-wheel. This test clearly demonstrated the superiority of the aluminium pulley.

At first thought it might seem that the over-run of a planer table is due more to the momentum of the table itself than to that of the driving pulley. The momentum of the table and work, however, is small as compared with that of the driving pulley. In this connection we quote the following words to show how the relative momenta of the table and that of the driving pulleys may be compared.

"The question now arises, from where does the planer get the momentum which will drive the table and work for perhaps several feet, and even sometimes chase it through a brick wall? Strange as it may seem, it gets this momentum from the driving pulleys, and, for a small portion, from the gearing. The momentum of a body, or the live energy which is stored up in it on account of its being in motion, is in proportion to its mass and the square of its speed. If, therefore, we multiply the weight of a body by the square of its speed, we obtain a number which is a measure for its energy, and which will enable us to compare this energy with that of some other body."

By comparing the energy of the table with that of the cast-iron driving pulley on a 36-inch by 10-foot planer, the momentum of the pulley was found to be over fifty-six times that of the table; in other words, if the momentum of the table itself was sufficient to cause an over-run of 1 inch, the momentum of the driving pulley would cause an over-run of approximately 56 inches. It is evident from this that it is the *momentum* of the pulley which should be reduced, and this has effectually been done by substituting the light aluminum alloy pulley. By comparing the momentum of the table with that of an aluminium pulley, it was found that the latter had a momentum only fifteen times greater than the table as against fifty-six times that of the table when using a cast-iron pulley of similar dimensions. Therefore, by the use of an aluminium pulley a reduction in the ratio of the momentum between the driving pulley and the table of over 70 per cent is obtained.

It is also interesting to know that the belts on planers equipped with an aluminium pulley were made 2 inches longer than on those planers having cast-iron pulleys and working under the same conditions, and more satisfactory results were obtained. The reduction of belt tension not only prevents undue wear of the belts, but also entirely eliminates the shrieking and burning up of the belts which is common to the heavy pulleys. This new pulley is similar in construction to the regular cast-iron type formerly used, the only decided difference being in the design of the arms which are made S-shaped, thus giving sufficient elasticity to prevent any breakage due to the arms shrinking away from the rim.—*Machinery.*

Composition for Pressed Decorations.—Six hundred parts of Cologne glue of the best quality, 300 parts rosin, 100 parts unboiled linseed oil, 8 to 10 parts of gelatine, and as much finely, sifted chalk as possible. The glue is steeped for two hours in cold water and the water must then be poured off completely and the vessel containing the soaked glue placed in steam or in boiling water, where the glue must be boiled until completely dissolved. The rosin and linseed oil are melted together in another fairly large vessel. When they are liquefied, add the gelatine which has also been dissolved meanwhile, very gradually and stirring continuously, as those substances do not combine well. When all the materials thus far are well dissolved, the mixture of rosin, linseed oil and gelatine is poured into the boiling glue, care being taken not to pour in the dirty rosin sediment, and mix the whole thoroughly together. In a box filled with sifted chalk, make a funnel-shaped depression, pour the fluid materials in and mix in as much chalk as it will take up. From this mass cakes are formed. Keep such as are not needed at once in a cool place—the cellar is best. When wanted they can be softened by steam.

Natural Gas*

Its Production and Utilization

By George S. Barrows

NATURAL gas belongs to that group of natural products of the earth known as bitumens. Other members of this same group are fluid petroleum, semi-fluid maltha and solid asphaltum. All these products have a similar general history and are found under similar conditions, and transitions from one to another may be often noted. Technically they are known as hydrocarbons, their constitution generally being hydrogen about 13 per cent and carbon about 85 per cent. Their utilization antedates history, but their technical and commercial importance to the civilized world is of quite recent date, or within, say, the last fifty years.

While natural gas is known, and to some extent made use of in nearly every country of the world, its production on a large scale is confined principally to this country, and here the main producing areas are in the northern parts of the Mississippi and Ohio River valleys, the mid-continental area in Kansas and Oklahoma, and in southern California; though in many States outside of these areas there has been or is a considerable production.

The main supply of the gas is, in the Appalachian field, from the Devonian to the upper coal measures. In northwestern Ohio and Indiana it emanates from the Trenton limestones or the Clinton limestones, and in Kansas and Oklahoma from the sandstones of the coal measures immediately above the Mississippi limestones.

The theories as to the origin of natural gas may be divided into two groups: (1) those which assume it is the product of an inorganic source as the result of chemical action on mineral matter, and (2) those which assume it is the result of a partial decomposition of animal or vegetable substances.

Of the inorganic theory there are two notable examples: first, that the alkaline metals exist in the interior of the earth in a free or uncombined state, and necessarily at a high temperature. If now, water, carrying in solution carbonic acid finds access to these metals the result would be the formation of a series of hydrocarbon compounds. Second, the interior of the earth may be supposed to contain large masses of metallic iron and metallic carbides, all at high temperature. Water in contact with such substances under these conditions would generate metallic oxides and hydrocarbons.

To the theory of organic origin there are also two general groups of adherents. One supposes that natural gas is produced from the primary decomposition of organic matter in the rocks containing such matter; for it is well known that the decomposition of such substances in the absence of air will form products similar to natural gas. The other assumes a secondary decomposition of the organic matter stored in the rocks, that is, the animal and vegetable matters have suffered a partial transformation and are now held in the rocks as hydrocarbon compounds and from these, by a process of distillation, the gas is derived.

The gas is stored in porous rocks such as sandstone or limestone with an impervious covering of shale or similar rock. These reservoirs of rock are at varying depths ranging from a few hundred to several thousand feet below the surface, but the gas is always in a porous rock overlaid with a non-porous covering.

While in many cases, in the same field these reservoirs may exist in lenticular form, it is usual for the various portions of the same field to be more or less in communication with each other, so that wells in one part of the field are more or less affected by the output of wells in other parts; but in no case can there be any large accumulation without the approximately impervious roof.

The disturbances of the strata have no little effect on the location of productive wells for it seems certain that the best wells are usually along the crests of the anticlinal fold, though many large wells have been found in or near the centers of synclines, where, however, there may be subordinate or secondary anticlinals.

The cause of the high pressure (usually many hundred and frequently several thousand pounds) is another source of speculation. One explanation is that the gas is capable of occupying a vastly greater space than that occupied by the materials from which it was derived; another is, the weight of the superincumbent rocks, but this one is of doubtful value for it could only be true if there were freedom of motion throughout the rock. A third explanation is that the hydrostatic pressure of the water always found near gas wells causes a head pressure of the gas in the traps formed by the anticlinals. This is the generally accepted theory and pressure conditions found in wells in various parts of the country seem to warrant its approval.

Different wells, even in the same field, show different analyses, but as a rule the characteristics of a field apply to all its wells, though there may be variations. The following table gives representative analyses of gas from the principal fields:

	Ohio.	Indiana.	Pennsylvania.	Kansas.
Carbonic oxide, CO	0.55	0.73	0.00	0.33
Hydrogen, H_2	1.89	1.86	0.02	0.00
Methane, CH_4	92.84	93.07	95.42	95.28
Ethylene series, C_2H_4, etc.	0.20	0.47	0.00	0.67
Carbonic acid, CO_2	0.20	0.26	0.05	0.44
Oxygen, O_2	0.35	0.42	Trace	Trace
Nitrogen, N_2	3.82	3.02	4.51	3.28
Hydrogen sulphide, H_2S	0.15	0.15	——	——

Ohio	B. t. u. per cu. ft.	948.15	(calculated)
Indiana	" "	922.62	"
Pennsylvania	" "	1252.00	"
Kansas	" "	973.08	"

A peculiar variation is the presence in some wells of large proportions of nitrogen as in:

	Princeton, Ill.	Dexter, Kan.
Carbon dioxid	0.10	0.00
Carbon monoxid	0.05	0.00
Oxygen	0.05	0.20
Methane	13.97	15.02
Nitrogen	85.83	71.89
Hydrogen	——	0.80
Inert media	——	12.09
	100.00	100.00

Broadly speaking, the drilling rig and tools for drilling gas wells are similar to those used for any driven well, though because of the great depths to which they are sunk the equipment is rather heavier and the tools more elaborate. Proper precautions must always be taken to prevent the caving of the sides of the well and the seepage of water to the gas chamber at the bottom. This is done by "easing" or inserting in the hole from the top to near the bottom, iron pipe of lighter weight than the gas conveying pipe which extends from the top to the bottom on the axis of the well. A gasket or washer called a "packer," inserted near the bottom, surrounds the gas pipe and extends to the periphery of the hole making a chamber for the gas which is collected here and taken to the surface by means of the central pipe.

From the top of the well the gas is led by a suitable pipe to the point of utilization. The pipe used is generally of wrought iron or steel; the small sizes are made up with screwed joints and the larger ones with some kind of coupling. The coupling generally used consists of a "center ring" which slips over the ends of the pipe to be joined, and a gasket of rubber at either end of this ring, the gasket being held tightly to the "center ring" by "follower rings" suitably drawn together by means of bolts. This makes a tight and strong but at the same time more or less flexible joint. The pipe is usually laid about thirty inches below the surface of the ground.

When crossing a stream a coffer dam may be built and the pipe laid in a trench in the bottom of the stream. If the stream be too wide or deep to conveniently build such a coffer dam, the pipe may be made up on shore and then hauled across and sunk. In any case, a number of small pipes, connected into a header on either side, are used in preference to one large pipe, both for the purpose of giving stability to the line and to insure a more certain supply in case of possible accident to the subaqueous line.

If the line is of considerable length, and the consumption is large or the well pressure low, it may be necessary to augment the well pressure. This is done by means of compressors, operated by any convenient means but usually by direct acting gas engines, which receive their fuel supply from the gas line itself. On long lines several such compressing stations may be necessary, for the friction loss in the pipe is large. Such long lines are: to Cleveland from West Virginia, about 120 miles of 18-inch and 12-inch pipe with a daily capacity of 83,000,000 cubic feet; to Cincinnati from West Virginia about 150 miles of 18-inch and 20-inch pipe with a daily capacity of 70,000,000 cubic feet; to Kansas City and other cities in northeastern Kansas and northwestern Missouri from Oklahoma, about 250 miles of two 16-inch pipes with a daily capacity of 90,000,000 cubic feet. All these lines have, at intervals, compressing stations of gas driven pumps. Some of the stations have a total capacity of over 10,000 horse-power.

The usual formula for the flow of natural gas is that of Pole as modified by Prof. Robinson:

$$Q = 48.4 \frac{T_1}{\sqrt{T_2\, T_0}} \sqrt{\frac{d^5}{L} (P_1 + P_2)(P_1 - P_2)} \frac{0.6}{g}$$

Q = cubic feet delivered per hour.

P_1 = absolute initial pressure in pounds per square inch.
P_2 = absolute terminal pressure in pounds per square inch.
d = diameter of pipe in inches.
L = length of pipe in miles.
T_0 = absolute temperature at maximum density of water 461 + 37 = 498 deg. Fahr.
T_1 = absolute temperature of gas after delivery.
T_2 = absolute temperature of gas flowing in main.
g = specific gravity; air = 1. To correct formula for other specific gravity than that given, multiply result by:

$$\sqrt{\frac{g \text{ in formula}}{g \text{ of other gas}}}$$

As the gas pressure in the main line is very high, sometimes reaching over 200 pounds, it would be impractical to distribute the gas at such a pressure in a city or town. It is therefore customary, at a point near the city line, to install a governor or regulator to reduce this pressure to one suitable for distribution in the city. The regulators are usually of the common diaphragm type. The pressure is reduced to either a few ounces, or the house pressure, or to a few pounds, at which pressure it is supplied through an intermediate main to various sub-reducing stations where it is again reduced to the house pressure. Or the gas may be distributed at a few pounds pressure and individual governors used, one being placed on each house service pipe.

For domestic purposes natural gas is used in the same way and with the same appliances as manufactured gas, though owing to its low candle-power it is seldom used for light with the open flame burner. With the incandescent mantle, however, it proves a most satisfactory illuminant.

Besides these uses, great quantities of natural gas are used as fuel for house heating, being burned in the fire-pots of hot air furnaces, hot water and steam boilers and in heating stoves as a substitute for coal, and its convenience and cleanliness make it most popular for these purposes.

For industrial purposes it is used as a substitute for coal or oil, in the smallest as well as the largest appliances, from the laundry water heater and china kiln to a high pressure steam boiler of many hundred horse-power and the large brick kiln of many arches.

It is used directly for the manufacture of carbon black and recently there have been many attempts at the production of gasoline by compression.

Because of its cheapness and relative ease of production there has always been great waste of natural gas. It is estimated that in West Virginia alone, as much as 500,000,000 cubic feet daily have been lost for a long period of years. Measures are now being taken by many States to so control the methods of production and utilization that this waste will be reduced or eliminated.

To give some idea of the immensity of the industry a few figures may be quoted from the United States geological reports.

In 1882 the approximate value of the natural gas produced was	$215,000
In 1890 the approximate value of the natural gas produced was	18,792,725
In 1900 the approximate value of the natural gas produced was	23,698,674
In 1909 the approximate value of the natural gas produced was	63,206,941

In 1909 the approximate distribution of the gas was as follows:

Producers	8,119
Consumers, domestic	1,223,438
Consumers, industrial	17,259
Gas consumed, domestic, cu. ft.	151,222,223,000
Gas consumed, industrial, cu. ft.	329,483,951,000
Average price for thousand cu. ft., domestic	24.23 cts.
Average price for thousand cu. ft., industrial	8.06 cts.

During 1909, 3,705 wells were drilled of which 778 were dry, leaving 2,927 productive. The total number of productive wells at the end of 1909 was 24,184 on a lease acreage of 8,746,982 acres.

Crystalline Coating for Wood or Paper.—A mixture of very concentrated solutions of salt and dextrine is applied as thinly as possible by means of a broad, soft brush to the surface to be coated. When dry, the coating is found to be colored like light mother of pearl and adheres firmly. Glass must, for this purpose, be coated previously with an alcoholic shellac solution. To stained glass it imparts a beautiful appearance. Paper must be sized, otherwise it will absorb the solution and prevent the formation of crystals. As salts, sulphate of magnesia, acetate of soda and sulphate of tin are well adapted.

*An abstract of a paper read by George S. Barrows at the fifth annual convention of the Illuminating Engineering Society, Chicago, and published in the *Transactions of the Society*.

Sanitary Engineering at Harvard University*

Ministering to Modern Needs

By George C. Whipple, Professor of Sanitary Engineering, Harvard University

THE Graduate School of Applied Science at Harvard University is founded upon the basic principle that engineering, using the word in the larger sense, is one of the learned professions; that the education required of one who enters this profession should be not only scientific and technical, but broad and humanitarian. The engineer of to-day must not only know the underlying principles of the mechanical sciences and be conversant with the details of his special work, but if he is to become the director of great enterprises he must have the power to think logically and reach conclusions quickly, write clearly and speak forcibly, not to mention such moral qualities as honesty, enthusiasm and that vague something termed personal magnetism. Some of these qualifications are inherent in the individual, some come with experience; but the power to think and speak and write should be a matter of early training, the knowledge of scientific principles should be acquired by the maturing mind and the application of these principles made the last step in the educational process. The instruction in applied science in its utilitarian aspect should be carried only far enough to illustrate general principles and to enable the student to take up some particular line of work intelligently and with such a degree of skill that he can earn a reasonable income during the early years after graduation, when he is getting his real experience in his chosen profession.

It is partly in response to the world's demand for broad-minded engineers, and partly because science itself is becoming so broad and its branches so interwoven, that the applied sciences are being taught more and more as graduate courses in our universities, and that the technical schools are looking forward to longer courses than the usual period of four years. The problem is everywhere the same, how to obtain a proper balance between breadth of study and specialization. That specialization has been somewhat overdone in the past seems to be the verdict of employers; on the other hand, it is equally true that in the attempt to combine various sciences relating to one vocation there has been sometimes too great a dispersion of thought and interest.

Sanitary engineering is one of the fields where there is great danger that the students' energies may be spread out too thin. For this branch of engineering is one that invokes the aid of many sciences. Not only must the sanitary engineer be versed in mathematics and mechanics, but he must have a working knowledge of parts of chemistry, biology, bacteriology, microscopy, meteorology, geology, hygiene, preventive medicine and vital statistics. Unlike other branches of engineering, sanitation is concerned not alone with iron and stone and other inert building materials, but with organic matter and living things. The purification of water and sewage is due largely to biological action, and the knowledge of bacterial processes is scarcely less important to the sanitary engineer than that of the laws governing the flow of water in pipes and the strength of materials. While this is acknowledged, it is also true that, first and foremost, the sanitary engineer must be an *engineer* and the collateral sciences subordinated to the main issue. In arranging the new courses in sanitary engineering at Harvard University this idea has been dominant.

But sanitary science is becoming so important that there is room not only for the engineer but for the sanitary specialist, for the man who devotes his energies to the chemical and biological problems apart from engineering design. Men of this type are now doing useful service, but the need for such men is limited in number when compared with those required to build and operate water-works and sewage-disposal plants, lay out streets and keep them clean, ventilate cars and buildings and otherwise apply the principles of engineering to public hygiene. Many young chemists and bacteriologists have become successful in the operation of engineering works, as, for example, water-filtration plants, but it has been because they have obtained their engineering knowledge in the school of experience; on the other hand, some who have been ambitious in this direction have soon reached the limit of their ability. Such positions are best filled by men of adequate mechanical-engineering training, with a knowledge of chemistry and biology sufficient to enable them to make the necessary routine analyses.

Besides the sanitary engineer and the specialist in sanitation, the world to-day needs, and the need is very great, a kind of man just beginning to make his appearance, the sanitary executive, or, as he is more often called, the health officer. There are already many so called health officers serving on boards of health. Some of these men are great leaders, well worthy of the honorable positions they hold, but the rank and file of them are ill-fitted for their important task. Our public-health machinery was installed when the hygienic wisdom of the town was wrapped up in the family doctor and when the physician was the logical custodian of the public health. With the growth of the science of bacteriology and preventive medicine and the application of engineering all this is changed. The ability to diagnose a case of small pox and keep a record of deaths is no longer a sufficient qualification for the health officer of even a village, while the growth of our cities is continually demanding that the man in charge of the public health of so many people shall be an expert in his line.

Medical training alone does not fit men for this service. The problem of curing disease is quite different from the problem of preventing disease. The former deals with human beings as individuals; the latter considers them as units of a mass. The prevention of disease involves mathematics; statistics relating to the sick and the dead must be constantly and daily used in order to show what forces of disease are at work, and where the attack is next likely to be made. It involves engineering; for the public must be protected against impure air and infected water, streets must be cleaned and garbage removed. It involves chemistry; for the public must be protected against the sale of adulterated and poisonous foods. It involves bacteriology; for infectious diseases must be diagnosed and antitoxins provided. It involves law; for the health officer must be able not only to discern evils but to eradicate them. But the duties of a health officer should not be entirely repressive and punitive. There is a positive side. His department should be an educational force in the community, constantly instructing the people in the arts of hygiene and in the principles of right living. Many believe that this educational function of the health officer is one of the most important of his duties.

Harvard University aims to provide instruction for sanitary engineers, for those who desire to become specialists in sanitation and for those who desire to become public-health officers. This work is just beginning and the courses first provided and now being given are intended primarily for students of engineering and for those who are candidates for the degree of doctor of public health in the medical school. Later it is planned to broaden the field.

The headquarters of the sanitary-engineering course is in Pierce Hall, Cambridge, where, during the past summer, a laboratory was fully equipped for the analysis of water, sewage, air, filter sand, etc., and for research work in water filtration and sewage purification. A part of the latter work will be carried on in the field at various plants scattered through the State, thus putting the student in contact with actual works in operation. The instructing force includes a professor of sanitary engineering and two instructors in the laboratory, one a specialist in bacteriology, the other, in sanitary chemistry.

Two courses are offered during the present academic year. The first is a general introductory course in sanitary engineering, intended for civil engineers who do not wish to specialize in this direction, for students of the medical school, and for other properly equipped graduate students in the university. This is a lecture and recitation course with little laboratory work. The topics to be covered are water supplies and water purification; rainfall and runoff from watersheds; storage of water; stream pollution; sewerage and sewage disposal; garbage disposal; street cleaning; disposal of trade wastes; plumbing; ventilation; public health; vital statics; applications of biology and chemistry.

The second course is a specialized course intended primarily for engineers who intend to practice sanitary engineering. It consists of three parts. Part A is a course of laboratory work in the physical, chemical, microscopical and bacteriological analysis of water and sewage, air analysis, analysis of filter sand, etc. It is given during the first term and is in charge of the instructors. Part B is a continuation of Part A and is largely a research course, involving original investigations and field work in subjects connected with water purification, stream pollution, sewage purification, and the disposal of factory wastes. It is given during the second term and is in charge of the professor of sanitary engineering and the instructors. Part C is a course in sanitary design which will be taken up in connection with, and as a supplement to, the course in the theory and design of structures given by Prof. George F. Swain. It is devoted particularly to the design and operation of water-works, filter plants, sewerage systems and sewage-disposal works. It is given during the second term and is in charge of the professor of sanitary engineering and an instructor in civil engineering. Those who wish to devote particular attention to this phase of the subject may omit the laboratory work and devote equivalent time to problems of design. On the other hand, those who wish to devote their attention specially to the laboratory work may omit the course in sanitary design. It is not expected, however, that candidates for the degree of civil engineering will do this.

No special degree is given in sanitary engineering, but the courses above referred to are accepted as a part of the work specified for the degree of Master in Civil Engineering (M. C. E.), this being in accord with the idea advanced at the beginning, that the sanitary engineer should be essentially an engineer.

During the early years, while the number of students is comparatively small, these courses will be thrown open to qualified students not candidates for the master's degree. It is thought that engineers in practice, or those who desire to take up some particular line of research will avail themselves of this opportunity.

The Harvard University Medical School now offers courses leading to the degree of Doctor of Public Health (Dr. P. H.). Although candidates for this degree are recommended to take the medical courses by way of preparation, these are not demanded as prerequisites and arrangements will be made for specialization in sanitary engineering, sanitary chemistry, or sanitary architecture. The degree will be given after four years' work in such branches, or, in the case of medical graduates, after one year's work, provided that the last year's work in the medical school has included certain foundation studies, such as advanced bacteriology, protozoology and preventive medicine. The ability to conduct original research is considered essential for the attainment of this degree. It is the intention of the university to maintain the scholarship involved in acquiring this degree at the highest possible standard, the object being to educate men for leadership in sanitary science. Dr. M. J. Rosenau, Professor of Preventive Medicine and Hygiene, is chairman of the faculty committee on the degree of Doctor of Public Health.

For those who desire to fit themselves as health officers, it is believed that the course in sanitary engineering, supplemented by certain courses in the medical school, the law school and the university, made possible by the free elective system in vogue at Harvard, will furnish an admirable training.

* From Bulletin of the Society for the Promotion of Engineering Education, January, 1912.

Ice That Will Not Float

"THERE are four, possibly six different forms of ice," says an anonymous writer in *Science Conspectus*. "These may be divided into two groups, those forms that are lighter than water and those that are heavier. Under the first head come: Ordinary hexagonal ice, called ice 1, such as is formed on the window pane in winter or in snow; a form called ice 4; tetragonal ice, so called because of its crystalline form, observed by Nordenskiold; ice crystallizing in the regular system, observed by Barendrecht. Ice 4 is probably identical with one or other of the two latter forms.

"If water is cooled very slowly the temperature may be lowered considerably under 0 deg. Cent. before the water freezes. Ice 4, which is slightly lighter than ordinary ice, is usually formed under these conditions. Increasing the pressure to several hundred atmospheres especially favors the formation of this variety of ice. It changes very readily into ice 1 and invariably does so if the pressure is released and the temperature is raised to nearly 0 deg. Cent. Ice 1 is the stable form at all pressures under 2,200 atmospheres, if the temperature is not below —130 Cent.

"If water is subjected to a pressure exceeding 2,500 atmospheres and the temperature is lowered sufficiently a solid, called ice 3, is formed. This form is heavier than water and sinks to the bottom. If the pressure is suddenly released ice 3 explodes into a white powder resembling snow which proves to be ice 1. Ice 2, which closely resembles and which readily turns into ice 3, may be formed by subjecting ice 1 at —80 deg. Cent., to a pressure of 2,700 atmospheres.

"It is interesting to note that a vessel filled with water will not burst when the water freezes if the vessel is capable of withstanding a pressure exceeding 2,500 atmospheres because ice 3 will be formed which takes up less room than the water itself."

To Preserve Birdlime.—Keep it in the retail sales package, covered with water, to which, at most, 0.5 per cent of sulphuric acid has been added. Old and possibly molded birdlime, may be restored by working it in a bath (0.5 to 1 part of bichromate of potash, 2 parts English sulphuric acid, and 80 to 100 parts of water) and allowing it to steep therein for 1 to 2 hours. Take it out, wash it out well in clean water and press out until the water runs off clean and uncolored.

Reviews of New Books

THE SPELL OF FRANCE. By Caroline Atwater Mason. Boston: L. C. Page & Co., 1912. 8vo.; 425 pp.; illustrated. Price, $2.50 net.

It is Southern France—old France—which for Caroline Atwater Mason casts such a glamor into the eyes. In reading her charming volume we are compelled to admit, not only the spell of the Midi, but also the spell of her pen. For she belongs to that limited guild which acceptably imparts reality and vitality to historical and topographical description by the injection of the personal element—the hint of personal moods, impressions, disappointments, appreciations, and humorous episodes, without which such narratives of travel are uniformly dusty and dry. The informative parts of the work are none the less capably wrought, and among the profusion of admirable illustrations we find many scenes of loveliness which go far toward establishing the aptness of the title.

HOW TO GROW ONE HUNDRED BUSHELS OF CORN PER ACRE ON WORN SOIL. By William C. Smith. Cincinnati: Stewart & Kidd Company, 1912. 12mo.; 188 pp.; illustrated. Price, $1.25 net.

While titles such as the above are generally ill-advised, in the present instance the matter thus introduced is worthy of careful consideration. The author has given much study to the possibility of restoring worn-out soils at the same time that profitable crops are grown upon them. His method is to plant first to early peas, then, immediately after, to sugar corn. Early in August he plants in the sugar corn vetch or rye—preferably vetch. The following spring he plows under the vetch and the cornstalks, and plants to field corn. By continuing in this manner he claims that in two seasons he is enabled to grow from fifty to one hundred bushels of corn to the acre on almost any worn-out soil. In short, the secret of his success is the introduction, each year, into the soil, of large quantities of organic matter containing the renewing elements which the ground requires. Supplemented with soil covering and some manure, this method has resulted in high fertility and bumper crops.

THE TEACHING OF PHYSICS FOR PURPOSES OF GENERAL EDUCATION. By C. Riborg Mann. New York: The Macmillan Company, 1912. 12mo.; 304 pp. Price, $1.25 net.

The question whether the schooling of the day should seek mainly to cultivate the mind in a general way, or should apply itself definitely toward fitting the student to earn his living, is daily becoming more insistent. Prof. Mann deprecates such distinctions between cultural and vocational work, and seeks in the present volume to show how their conflicting claims may merge to a common viewpoint with benefit to results both theoretical and practical. Indeed, if a man does not find culture value in his life work, whatever it may be, the life itself must certainly be a failure in the deepest sense of the word. The first division of the work traces the development of the existing situation; the second traces the origin of physics, giving its distinctive features and defining its usefulness in any plan of general education; while in the third and final division the purpose underlying the teaching of physics is outlined, and a plan whereby this purpose may best be attained is suggestively indicated.

HISTORICAL PAPERS ON MODERN EXPLOSIVES. By George W. MacDonald, M.Sc. With an introduction by Sir Andrew Noble, Bart., K.C.B., F.R.S. New York: The Macmillan Company, 1912. 8vo.; 192 pp Price, $2.50 net.

The work consists of a series of papers first published in *Arms and Explosives*. It gives the history of the discovery of fulminate, of nitrostarch, and of guncotton. The development of guncotton takes up the greater portion of the volume, and cites the various patents, the experimental work of different nations and governments, with the researches of Abel and the gist of his conclusions. Sobrero's discovery of nitroglycerine, with the history of this explosive in Holland and England, takes up two chapters; the analysis of its composition is given a third; and its chemical decompositions are considered in a fourth and fifth. The Nobel patents for the manufacture and detonation of nitroglycerine, dynamite, blasting gelatine and ballistite are also discussed. The work presents in condensed and convenient form much history and research that must otherwise be obtained by the arduous pursuit of old and evasive publications. Hence, all who are in any way interested in explosives will find here a valuable fund of information.

ROME. By W. Warde Fowler, M.A. New York: Henry Holt & Co., 1912 16mo.; 256. Price, 50 cents net; by mail, 56 cents.

In following out the plan of forming a newly-written, comprehensive body of literature dealing with modern knowledge, the editors of the "Home University Library" present, among other works, a number treating of countries and places noteworthy by reason of past history, present achievement, or promise as to the future. "Canada" is considered geographically, historically, as a power in present-day activities and as a factor to be reckoned with in days to come. The busy American will find much meat here compressed into tabloid form by one who has made careful study of his subject and who is known as the author of other volumes bearing upon Canada in the making. "Rome" is a brief history of the life of the ancient state from the time when her boys "tired out the whirlwind" and her men "shook towns in war" to the dark days when, weakened by pestilence and overrun by German tribes, she entered upon the downward course that could but end in ruin. Our indebtedness to Roman character and Roman law is traced, and the warring elements of dominion and degeneracy furnish us lessons that may well be applied to our own problems of to-day.

FACTORY MUTUAL INSURANCE. Boston: Arkwright Mutual Fire Insurance Company, 1912. (Privately printed.) 8vo.; 123 pp.; illustrated.

The Arkwright Mutual Fire Insurance Company, one of the "factory mutuals" of New England, tells the story of the control of fire waste in manufacturing plants, and of the progress made in the past fifty years in preventive measures and devices, with the consequent lessening of insurance cost from 45 cents on the hundred dollars insured in 1850-1860, to 4½ cents in 1910 and 1911. A colored insert shows a layout of fire protection in a machine shop, as recommended by a special inspector and attached to his written report.

THE SCIENTIFIC DIAL PRIMER. By A. Hallner. San Francisco: Sunset Publishing House, 1912. 8vo.; 160 pp.; illustrated.

The author, struck by the simplicity and utility of the clock dial for recording time, dates, and phases of the moon, has devised a dial chart that, without resort to mechanism, contains varied elements of mathematics and language which are made readily available for universal use in computation, in code communication, and in other ways which a study of the primer will disclose. It offers a universal language at a minimum expenditure of time and labor, and is quite a monument to the ingenuity and industry of its inventor. The system comprises twelve classes of keys, by means of which an ordinary message may be translated into code form and back again, the extraordinary number of key-shifts being guarantee against the translation of the code by anyone not holding the right key. An advantage claimed is that of economy. "March 1st, 1911," for example, being translatable into code as "Dabelana"—one word in place of several. As the primer sets forth only the rudiments of the author's system, he will presumably follow it with a more advanced exposition.

THE METALLURGY OF STEEL. By F. W. Harbord, Assoc. R.S.M., F.I.C., and J. W. Hall, Assoc. M.Inst.C.E. Fourth Edition, Enlarged and Revised. Philadelphia: J. B. Lippincott Company, 1911. Two volumes. 8vo.; 600 and 1,000 pp.; 51 folding plates, 500 illustrations in the text, and nearly 80 photomicrographs. Price, $12 net.

In issuing the new fourth edition of what has been for some years the standard work of reference on the metallurgy of steel, the addition of new drawings and much fresh material has made necessary two volumes in place of one. The first volume is devoted to the manufacture of steel and the finished product, the second volume to mechanical treatment. As might be expected, the last word in open hearth furnaces, charging machines and gas producers is embodied in the new drawings, and the chapter on electric smelting gives the recent advancement in theory and practice. The photomicrographs of the former edition are replaced by a completely new set, and plans of the very latest installations, giving the general design of modern plants in Europe and at home, are presented. The volume on mechanical treatment continues the comprehensive handling of its companion-work. In spite of the fact that mill and forge practice has been revolutionized during the past thirty years, it is hard to find a book which adequately explains how great masses of glowing steel are handled and worked with rapidity and economy. Mr. Hall attempts to supply this deficiency. His descriptions of furnaces, details of rolling mills, and explanation of the operations of the steam hammer and the press, may be commended as clear-cut presentations of elementary principles, intelligible to the ordinary student and useful to the practical man.

MODERN MICROSCOPY. A Handbook for Beginners and Students. By M. I. Cross and Martin J. Cole. With Chapters on Special Subjects by Various Writers. Chicago: Chicago Medical Book Company, 1912. 8vo.; 325 pp.; illustrated. Price, $2.

The microscope, from being little more than an ingenious toy in the hands of amateurs, has taken a most commanding position in the workshop of science. By the study of this book one may acquire a thorough knowledge of the construction of the modern instrument, its mirrors, condensers, polarizers, stage, and adjustments. Aid is given in the selection of a microscope for special needs and purposes. The second part of the volume is devoted to the preparation, staining, hardening and mounting of microscopic objects. The directions are shorn of all unnecessary complexity and, while such work is preferably learned by actual demonstration, the instruction here given should be very helpful. Animal and vegetable tissues, entomological specimens, crystals and diatoms are among the objects treated. Among the special papers which form the third part of the work is an introduction to the use of the petrological microscope, a paper on fresh water mites, and another on the microscopy of foods.

RAILWAYS IN THE UNITED STATES. Their History, Their Relation to the State, and an Analysis of the Legislation in Regard to Their Control. By Simon Sterne. (1839–1901.) New York: G. P. Putnams' Sons, 1912. 12mo.; 209 pp.

Simon Sterne was a member of the New York Bar, an advocate and jurist of international reputation, and an earnest student of transportation problems, particularly in their political and legal aspects. He died in 1901, but an attempt has been made by means of supplementary notes to continue the record to 1911. The three papers which comprise the body of the volume deal with the history and political development of railways; with legislation concerning, and management of, railways in the United States; and with the relation of railroads to the State. The discussion is still eminently pertinent to present-day problems, and the arguments are put forward with a clarity and force behind which is deep knowledge and public-spirited interest. Subsidies, panics, investigations, commissions, and federal regulation; bases of charges, secret tariffs, minority representation, and fictitious capitalization—these and many other phases of the complex subject are stated in the masterly way to be expected of so distinguished a jurist and so broad-cultured a man.

ENGINEERING AS A VOCATION. By Ernest McCullough, C.E. New York: David Williams Company, 1911. 8vo.; 201 pp. Price, $1.

The engineering professions call for a peculiar combination of moral integrity and intellectual efficiency. It is with the object of informing parents as to the necessary qualifications and the means of acquiring them that this volume is written. It is full of truths that the average parent would be exceedingly unlikely to stumble upon elsewhere—and then certainly not in the logical arrangement which here so forcefully sets forth allied facts and conditions. Home study courses, their helpfulness and their limitations, are given a chapter, and "How to Hunt and Hold a Job" and "Does It Pay to Study Engineering?" are two other chapters of very practical bearing. The parent and the youthful student alike may profit by a reading of this frank series of papers written by one who is on the inside of things.

APPLIED PHYSICS FOR SECONDARY SCHOOLS. By V. D. Hawkins. New York: Longmans, Green & Co., 1912. 8vo.; 200 pp.; illustrated. Price, $1.

"Applied Physics" is a very short text which endeavors to present the study in a live and vital manner, as "a reasonable explanation of the every-day events of life." Only simple, basic principles are given, with a few interesting applications found in the common experiences of life, while teacher and pupils are expected to contribute further applications by reasoning from familiar objects and actions. The author deems most first-year text-books of this nature to be overburdened with a confused mass of material, and so frames and limits his own text to avoid this error.

BEYOND WAR. A Chapter in the Natural History of Man. By Vernon Lyman Kellogg. New York: Henry Holt & Co., 1912. 12mo.; 172 pp. Price, $1.

Evolution is a reality; evolution is progress; and the author sets forth his reasons for the faith that is in him—that War must become obsolete with the raising of the plane of life. His arguments are not moral or religious in the restricted use of the terms, but are based upon what may be designated as the mechanics of evolution. Whether the reader may agree with all his conclusions or not when it comes to the laying down of the volume, the discussion will have proved interesting in a high degree, and knowledge will have been gained that is well worth the acquiring

THE MUSICAL MEMORY AND ITS DERANGEMENTS (AMUSIA). By J. Leonard Corning, M.D., LL.D. New York: William Wood & Co., 1912.

The human mind is subject to peculiar vagaries when its material organ, the brain, becomes in any way affected by morbid changes or lesions. Perhaps the most striking disturbances of the psychic mechanism are not those which completely overthrow the mental balance of the individual, but those which, while leaving him otherwise perfectly sane, deprive him of some one or other specific faculty, of the very existence of which he may up till then have been in ignorance. Disturbances of this character are those known technically as aphasia, which may take on a variety of forms, though they all relate to our faculty of intelligently appreciating sounds such as words, and our power to make ourselves understood by such sounds. Thus the psychiatrist distinguishes between sensory aphasia, in which the patient is unable to understand spoken words or in some cases unable to read written language, and motor aphasia, in which the person has lost his power of uttering words, although his vocal organs are in perfectly good condition and under normal control. A very special kind of aphasia forms the subject of Dr. Corning's memoir, namely, aphasia in which the musical faculties are affected. The author discusses at length the *rationale* of such conditions, and quotes a number of most interesting examples from literature on the subject. Dr. Corning's paper is couched in such language as to appeal to all, not only the layman who naturally takes an interest in matters pertaining to some of the most essential functions of the human mind, but also to the specialist, and in particular to the musician, who will find instructive and entertaining reading in those pages dealing with a disorder which fortunately does not very frequently afflict the professional musician. The subject could hardly have been discussed by an abler man than Dr. Corning, for he happens to be not only a physician of note, but one who is a musician himself.

A. J. L.

DARK ROOM WORK. A Practical Dark Room Manual, with Suggestions as to Equipment; Working Conveniences; Short Cuts and Handy Methods of Dark Room Work. New York: Tennant & Ward, 1912. Price, 25 cents.

FLASHLIGHT PORTRAITURE. A Book of Common Sense Information and Practical Methods of Making Portraits by Flashlight at Home or in the Photographic Studio. Fully Illustrated. New York: Tennant & Ward, 1912. Price, 25 cents.

The titles and sub-titles of these paper-covered manuals are sufficiently comprehensive to indicate the scope of the papers and the main points of treatment. They offer in inexpensive form advice and information that the beginner will find to be thorough and practical.

THREE WONDERLANDS OF THE AMERICAN WEST. By Thomas D. Murphy. With Sixteen Reproductions in Color from Original Paintings by Thomas Moran, N.A., and Thirty-two Duogravures from Photographs. Boston: L. C. Page & Co., 1912. 8vo.; 180 pp. Price, $3 net.

Artist and author have collaborated in a work of great beauty to impress upon American readers the almost incredible wonders of the scenic offerings of their own great West. The reproductions in color of Moran's well-known paintings retain in a remarkable degree the original values in warm light and cool shadow, in rock and ripple, in towering crag and ragged foliage. The boiling waters, bordered by rainbows and flashing diamond-facets to the sun; the myriad tints that gleam, melt and merge upon the sheer walls of the deep-hewn canyons; the sense of space, of majesty, almost of infinity that broods over all the wide-flung panorama, and brings an indescribable peace to town-sick souls—all this is brought vividly before us as we follow the author's enthusiastic descriptions or linger over the artist's inspired interpretations. The work, however, is more than a rhapsody in language and pigment. It contains maps of the Yellowstone, Yosemite, and Grand Canyon regions, and offers other aids that contribute to the comfort and convenience of the tourist, besides delving here and there into geology and history.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical or scientific knowledge required therefor.

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